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THE BENEFIT ASSESSMENT ROLE OF EPN

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A Report of the
USDA-STATES-EPA
EPN RPAR
Assessment Team

This report is a joint project of the U.S. Department of Agriculture, the State Land Grant Universities, and the U.S. Environmental Protection Agency. It was recently prepared by a team of scientists from these organizations in order to provide sound, current, scientific information on the benefits of, and exposure to, EPN.

The report is a scientific presentation to be used in connection with other data as a portion of the total body of knowledge in a final benefit/risk assessment under the Rebuttable Presumption Against Registration Process in connection with the Federal Insecticide, Fungicide, and Rodenticide Act.

May 20, 1980

II. Table of Contents

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List of Tables

List of Figures

Abstract
Introduction

Pesticide insecticide used ... insect pest

... corn, vegetables ... and ...

EPN is efficacious and ... comp...

Its use is on cotton in the delta region ...

... with methyl parathion, it is the most ... insecticide

... treatment of *Heliothis* spp., bollworm and ...

... and Mississippi ...

... with EPN + methyl parathion ...

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EPN is very limited in its use ...

... insecticides are more generally available ...

... effective. EPN is currently ...

... in their control programs. ...

... have developed resistance to certain insecticides.

... alternative insecticide such as EPN available ...

... desirable.

... although it is registered to control

major insect pests attacking this crop.

V. Abstract

EPN is an effective insecticide used to control insect pests on cotton, soybeans, corn, vegetables, pecans and peaches. Although in most cases EPN is efficacious and cost competitive, its most extensive present use is on cotton in the delta region of the U.S. When EPN is used with methyl parathion, it is the most cost effective insecticide for treatment of Heliothis spp., bollworm and tobacco budworm.

Arkansas and Mississippi annually treat a portion of their soybean acres with EPN + methyl parathion to control soybean insects. EPN is not used on soybeans in the north central states since pest problems are much less frequent and alternative insecticides are available on the farm or readily available from local dealers.

EPN is very limited in its use on corn and vegetable crops because other insecticides are more generally available and are equally or more effective. EPN is currently not being used by mosquito abatement personnel in their control programs. Because several mosquito species have developed resistance to certain insecticides, having an effective alternative insecticide such as EPN available for use if needed would be desirable.

EPN has limited use on pecans although it is registered to control most of the major insect pests attacking this crop.

VI. INTRODUCTION

A. Purpose of Report

The purpose of this report is to indicate the benefits of the registered uses of the organophosphorus insecticide EPN. EPN is registered for control of a variety of insects which attack cotton, corn, soybeans, sugarbeets, various nut, fruit and vegetable crops and as a mosquito larvicide for use in non-fish-bearing waters.

B. Brief History of Use

EPN is classed and used as a nonsystemic insecticide-acaracide and is available in emulsifiable concentrates, dusts, wettable powders, and granular formulations. The standard commercial formulation is an emulsifiable concentrate alone or in combination with another insecticide. Emulsifiable concentrations of EPN ranges from 9.1% to 55% in these various formulations. EPN is registered in combination with methyl parathion, Guthion, toxaphene, and parathion (47). EPN also has state registrations to be used in combination with Sulfur and chlordimeform.

Tolerances have been established ranging from 3 ppm down to negligible residues of 0.05 ppm. Environmental Protection Agency records indicate that 4,126,500 pounds of EPN were used in the United States during 1974 (44). Of this total, about two pounds were used in industry; 8,000 pounds were used in government; and 4,118,500 pounds were used in agriculture. Of the agriculture total, 4,500 pounds were used on beans;

326,000 pounds on corn; and 3,788,000 pounds on cotton. Because of insects' resistance to other insecticides, EPN usage was reported to be 6,140,000 pounds in 1976, most of which was used on cotton.

EPN has been produced as an insecticide since 1950 and 26 registrants produce 72 registered products. In addition, six companies formerly held state registrations for ten products (47).

C. Reason for RPAR

On September 19, 1979, the Environmental Protection Agency issued a "Rebuttable Presumption Against Registration and Continued Registration of Pesticide Products Containing EPN: (175) The Agency's action was based on the following presumptions:

1. Delayed Neurotoxicity

40 CFR 162.11(a)(3)(ii)(B) provides that a rebuttable presumption shall arise if a pesticide "(p)roduces any other chronic or delayed toxic effect in test animals at any dosage up to a level, as determined by the Administrator, which is substantially higher than that to which humans can reasonably be anticipated to be exposed, taking into account ample margins of safety...." The Agency has concluded that all pesticides containing EPN exceed the chronic risk criterion relating to delayed neurotoxicity. However, the Environmental Protection Agency indicates that when assessing the risk of EPN to human health, the lowest tested dosage (0.01 mg/kg per day) has not produced either histological changes or clinical signs indicative

126,000 pounds on corn, and 1,[illegible] pounds on [illegible]. Be-
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the risk of EPN to human health. The
(0.0) [illegible] per day and the [illegible]
or clinical signs indicative [illegible]

of delayed neurotoxicity in the most sensitive species (no observed effect level, or NOEL). But based on the exposure estimates discussed in 44 CFR (185) III. A. (175), the Agency concludes that the anticipated amount of EPN to which pesticide applicators and unprotected bystanders may be exposed by the dermal (and, in some instances, by the inhalation) route may not provide an ample margin of safety.

2. Acute Hazard to Wildlife: Aquatic Species

40 CFR Section 162.11(a)(3)(i)(B)(3) provides that a "rebuttable presumption shall arise if a pesticide's (use)...(r)esults in a maximum calculated concentration following direct application to a six inch layer of water more than one-half the acute LC_{50} for aquatic organisms representative of the organisms likely to be exposed as measured on test animals...."

EPN is registered for use by mosquito abatement districts, public health officials, and other trained personnel of public mosquito control programs as a mosquito larvicide. Application rates for EPN as a mosquito larvicide are 0.05 to 0.1 pound active ingredient/acre using ground or aerial equipment. Because both the lower rate (0.05 pounds AI/acre) and higher rate (0.1 pound AI/acre) will exceed one-half the LC_{50} or TL_m for all but one of the aquatic species tested, the Agency issued a rebuttable presumption against all pesticide products containing EPN which are registered for direct application to water.

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(no observed effect level or NOEL), but based on the
exposure patterns discussed [illegible] III. A. [illegible]),
the Agency concludes that the small [illegible] amounts of
to which [illegible] may
may be exposed [illegible] the dermal [illegible] some instances
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of safety.

Acute Hazard to Wildlife [illegible] Aquatic Species

[illegible] Section 162.11(a)(3)(ii)(B)(3) provides that
a [illegible] that this presumption shall [illegible] a pesticide
(use) [illegible] results in a maximum calculated [illegible] concentration
following direct application [illegible]
more than one-half the acute LC50 [illegible]
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PROPERTIES OF EPN

A. Physical and Chemical Properties of EPN

Trade Name: EPN

Common Name: EPN

Chemical Name: O-Ethyl-O-p-nitrophen[illegible]

Other Chemical Names: ethyl p-nitroph[illegible]

O-Ethyl-O-p-nitrophenyl Ben[illegible]

Structural Formula:

Empirical Formula: $C_{14}H_{14}NO_4PS$; Molecular [illegible] 323

Color and State: pure-light-yellow, crystall[illegible]

technical grade [illegible]

Specific Gravity: 1.27 at 25°[illegible]

Melting Point: 34.5 [illegible]

Solubility: Slightly soluble in water [illegible]

benzene, toluene, [illegible]

alcohol and methanol.

Stability: Hydrolytic half-life [illegible]

and temperature of 12°C [illegible]

Compatibility: Registered in combination with [illegible]

Lathion, toxaphene and parath[illegible]

[illegible] Pressure: 0.03 mmHg at 100°C

[illegible]

EPN in the air, soil, w[illegible] and plants [illegible]

[illegible] reviewed in the PD-1 (1[illegible]) so it would

[illegible] presentation here.

Properties of EPN

VII. PROPERTIES OF EPN

A. Physical and Chemical Properties of EPN

Trade Name: EPN

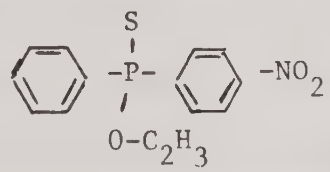
Common Name: EPN

Chemical Name: 0-Ethyl-0-p-nitrophenyl phenylphosphonothioate

Other Chemical Names: ethyl p-nitrophenyl thionobenzene phosphate

0-Ethyl-0-p-nitrophenyl benzene thiophosphonate

Structural Formula:



Empirical Formula: $C_{14}H_{14}NO_4PS$:Molecular Weight: 323.3

Color and State: pure-light-yellow, crystalline powder

technical grade reddish-yellow, oily liquid

Specific Gravity: 1.27 at $20^{o}C$

Melting Point: $34.5^{o}C$

Solubility: Slightly soluble in water and is miscible with benzene, toluene, xylene, acetone, isopropyl alcohol and methanol.

Stability: Hydrolytic half-life is 40.9 hours at a pH of six and temperature of $72^{o}C \pm 2^{o}C$

Compatability: Registered in combination with methyl parathion, Guthion, toxaphene and parathion.

Vapor Pressure: 0.03 mmHg at $100^{o}C$

B. Fate of EPN in the Environment

1, 2, 3, & 4

The fate of EPN in the air, soil, water and plants and animals was thoroughly reviewed in the PD-1 (175) so it would seem redundant to duplicate a presentation here.

C. Possible Miscellaneous Uses of EPN

The assessment team was concerned that some important, but not well-known uses of EPN, would be overlooked in the benefit assessment analysis. For this reason, the USDA National Agricultural Pesticide Impact Assessment Program was solicited to help the EPN Assessment team locate information on the use of EPN in each state. In a letter dated January 7, 1980 from Nancy Ragsdale to each state's Pesticide Impact Assessment Program contact person, a request was made for information on sites, acreage, quantities used, application techniques, pest management programs, etc. The information was to be sent to the EPN team leader by January 25, 1980.

The responses to this request are shown in Table 1. The assumption must be made that the states not responding to the request have little or no EPN usage.

Table 1. Response to Pesticide Impact Assessment Program Survey of EPN Use.

STATE	NO RESPONSE	DIRECTLY TO APPROP. EPN TEAM MEMBER	RESPONSE INDICATED LITTLE OR NO EPN USE	RESPONSE INDICATED AMOUNT OF EPN USED: ACRES	INSECT	RESPONSE SHOWN BY INCICATED FOOTNOTE
NE REGION						
Maine	X					
Vermont	X					
N. Hampshire	X					
Massachusetts	X					
Connecticut	X					
Rhode Island	X					
New York				22,400	sweet corn ECB	1/
MID ATLANTIC						
Pennsylvania	X					
New Jersey			X			
Delaware	X					
Maryland			X			
Virginia	X					
West Virginia			X			
SOUTHEAST						
North Carolina		X				
South Carolina		X				
Tennessee		X				
Georgia		X				
Florida			X			
Mississippi		X				
MIDWEST						
Michigan		X				
Ohio						2/
Indiana	X					
Kentucky				[2,500 field corn]	ECB	
Wisconsin				[2,690 sweet corn]	ECB	
Illinois				2,000	field corn ECB 2nd gen.	
Minnesota				3,000	sweet corn ECB	
Iowa				20,000	field corn ECB	
Missouri				30,000	field corn ECB	
North Dakota	X					
South Dakota				50,000	field corn ECB	
Nebraska				4,500	field corn ECB & Beetles	
Kansas				54,526 14,500	field corn-ECB field corn--western bean cutworm	3/

(CONTINUED)

(cont'd.)

STATE	NO RESPONSE	RESPONDED DIRECTLY TO APPROP. EPN TEAM MEMBER	RESPONSE INDICATED LITTLE OR NO EPN USE	RESPONSE INDICATED AMOUNT OF EPN USED — ACRES	INSECT	RESPONSE SHOWN BY INDICATED FOOTNOTE
SOUTH CENTRAL						
Arkansas		X				
Louisiana		X				
Oklahoma		X				
Texas		X				
WESTERN						
Montana	X					
Idaho	X					
Wyoming	X					
Colorado	X					
Utah			X			
Arizona		X				
New Mexico	X					
Nevada			X			
California		X				
Oregon	X					
Washington			X			
Hawaii			X			
Alaska	X					
MISC.						
Guam			X			
Puerto Rico			X			

1/ "The primary use of EPN in New York vegetable production is in the sweet corn areas. In fresh market production, EPN is not in widespread usage, but in the processing areas, EPN is a regular ingredient in management programs covering about 22,400 acres. Upon checking with processors, fieldmen, growers and county agents, I find that EPN is efficacious, economical, and would be greatly missed if it were to lose registration. Another standard for insect control, methomyl, has recently shown signs of weakness in my insecticide screening trials and in commercial production. If tolerance or resistance should ensue, EPN will be desperately needed in processing sweet corn insect control programs."--R. W. Straub, New York State Agriculture Experiment Station.

2/ "EPN is recommended in Ohio for use on tomatoes for the control of mites. The recommendations are as follows: EPN (4 lb/gal EC) 1/2 pint/acre and EPN (25% WP) 1 pound/acre. Ohio has approximately 900 acres of field grown fresh market tomatoes and approximately 18,700 acres of tomatoes for processing. However, our surveys indicate that if this chemical is used at all, it is used only on a very limited basis.

EPN is being added to the 1980 recommendations for sweet corn to control European corn borer. The recommendations will be as follows:

EPN (2% Granule)
EPN (4% Granule)] .25-.3 lbs. AI/acre

There was no use for this application in 1979. There were 15,000 acres of sweet corn harvested in Ohio during 1979."--Acie Waldron, Coordinator NCRPIAP and Robert L. Curtner, Technical Assistant.

3/ "In Kansas, we do not have any recent efficacy date concerning EPN. However, we currently have EPN included in our field crop insect control recommendations for the control of corn rootworm adult beetles. At one time, EPN was recommended for control of European corn borer, however, due to lack of information regarding its effectiveness, we decided to drop EPN from the recommendations for European corn borer control. Our records indicate, however, that EPN continues to be used quite commonly in Kansas. The record indicates that 45,526 acres of corn were treated with EPN for European corn borer control in 1978 and an additional 14,500 acres were treated for western bean cutworm control on corn. EPN is one of the few products registered for second generation European corn borer control. Other products include carbaryl as a spray or granules, toxaphene and Furadan granules. So far as we know, EPN is the only Federally labeled alternative to carbaryl that can be used for second generation European corn borer control on silage corn as an aerial spray application. Use of carbaryl is sometimes avoided where possible in mite prone areas.

Concerning economics, EPN currently costs from $1.50 to $3.00 per acre per application for the product while the most logical alternative, carbaryl, will cost about $3.00 to $4.50 per acre."--Donald C. Cress, Extension Pesticide Coordinator and H. LeRoy Brooks, Extension Specialist, Insecticides (Pesticidal Safety).

BIOLOGICAL AND ECONOMIC [illegible]

[illegible] I - COTTON

Major Uses - [illegible] on cotton

I. Commodity Information

a. Geographic distribution - Cotton [illegible] major

in the Carolinas, [illegible]

Mississippi, Missouri, [illegible]

[illegible], Texas, New Mexico, [illegible]

with a trace in three other [illegible]

b-c. Acreage - Production [illegible]

13,215,300 harvested a[illegible]

[illegible] lb. lint per harvested [illegible]

13,272,600 bales [illegible] $4.56 [illegible]

value of lint

[illegible] tons seed [illegible]

value of seed

d. Cultural practices - Cotton is grown [illegible]

seeds. [illegible] inches [illegible]

[illegible] inches apart, usually [illegible] Soil

thoroughly tilled three or more [illegible]

weed-free field with good soil [illegible] Fertilizer

is largely soil incorporated preplant, but there

is [illegible] sidedressing or foliar application of

[illegible] Herbicides are used preplant

Cotton

VIII. BIOLOGICAL AND ECONOMIC INFORMATION BY COMMODITY

SECTION 1 - COTTON

A. Major Uses - 98% on cotton

1. Commodity Information

a. Geographic distribution - Cotton is a major crop in the Carolinas, Georgia, Alabama, Tennessee, Mississippi, Missouri, Arkansas, Louisiana, Oklahoma, Texas, New Mexico, Arizona, and California with a trace in three other states (144).

b-c. Acreage - Production and Value. 1977-9 average (104).

13,215,300 harvested acres

497 lb. lint per harvested acre

13,372,600 bales @ 54.5¢/lb. = $3,667,572,000 value of lint

5,195,600 tons seed @ $98.67/ton = $505,299,000 value of seed

d. Cultural practices - Cotton is grown as a spring-seeded, full season annual crop - planted in rows 38-40 inches apart, usually on low beds. Soil is thoroughly tilled three or more times to give a weed-free field with good soil tilth. Fertilizer is largely soil incorporated preplant, but there is some side-dressing or foliar application of nitrogen or boron. Herbicides are used pre-plant

soil incorporated, surface applied pre-merge, directed post-emergence, and lay-by for weed control. Cultivation is used for weed control in the space between the rows. In arid or semi-arid areas, water is supplied by irrigation, either furrow or sprinkler. In the rain-belt, supplemental irrigation is a fairly common practice. Planting seed is usually fungicide-treated. In some cases, additional fungicides are applied in the seed furrow or mixed with the seed in the planter hopper-box. Some use of insecticides is made in the same manner as fungicides. Soil fumigation for nematode control is done, but is not a widespread practice.

When the crops are essentially mature, a defoliant or dessicant may be applied to prepare the crop for harvest. All harvesting is mechanical utilizing either spindle-type pickers or strippers.

2. Pest Information (See pages 34 and 35)

The key pests are the cotton bollworm, *Heliothis zea*, and the tobacco budworm, *H. virescens*. Both species occur belt-wide, but relative importance varies by regions.

Both species overwinter as diapausing pupae in the soil. The first generation is passed on legume and weed hosts. Summer generations occur at about

monthly intervals. Moths are night-flying, nectar feeders. Each species has a broad host range. The portion of the population of each species in cotton depends upon relative attractiveness and availability of the various hosts. Eggs are usually laid on the upper portion of the cotton plant. Larvae feed by boring into progressively larger squares and then bolls. The second generation often coincides with cotton beginning to square. Heavy loss of these small squares may cause a small delay in maturity, usually compensated for by the time of peak fruiting and is considered to be of very little or no direct economic importance.

The third generation occurs at a time when cotton is likely to be in a lush growing condition with lots of squares and quite a few tender bolls. Cotton becomes relatively more attractive than other hosts. Square damage rarely exceeds normal "physiological or weather-induced" shed and can be accepted. However, larger worms attack bolls, which is regarded as serious and usually irretrievable. These large worms have a high survival rate and are virtually impossible to control with any convention insecticide. It, therefore, becomes necessary to make an action decision no later than when the worms are in the egg or first 2+ larval

monthly intervals. The [illegible]

feeders. Each period [illegible]

The portion of the population of each [illegible]

cotton depends upon relative [illegible]

availability of [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

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cotton becomes relatively more [illegible]

other hosts. Since [illegible]

"physiological weather-factor" [illegible]

be [illegible]. However, [illegible]

which is regarded as serious [illegible]

able. These large areas [illegible]

and are virtually [illegible] to control with

conventional insecticides. It, therefore, becomes

necessary to move on to [illegible] tactics [illegible]

[illegible]

stadia. Decisions are based on counts of square damage or of insects with weight being given to plant condition, weather (including irrigation), and populations of predators.

The fourth generation, mid-August in Arkansas, finds cotton still an attractive host in most areas. With an increased boll-to-square ratio, the threat of damage from a given population is much greater. Insecticidal control is even more likely to be invoked than for the third generation. To further complicate matters, predator populations tend to be lower and the *Heliothis* population tends to shift toward the harder-to-kill tobacco budworm.

Much of the fourth generation may enter diapause. A fifth generation occurs in the warmer areas of the cotton belt with a long growing season. If cotton is still lush and squaring with warm temperatures and ample moisture from rainfall or irrigation, it may continue to be heavily infested. In such cases, the decision to make insecticide applications is based on the probabilities of susceptible bolls maturing into open, pickable bolls. This is a function of the likelihood of warm weather to mature the bolls and the yield potential - if the crop set is at

seedlings. Decisions are based on degree of insect attack, weight being given to plant condition, weather (including irrigation) and populations of predators.

A fourth generation, mid-August in Arizona, finds cotton still an attractive host in some areas. With an increased boll-insect load, the threat of damage from a fourth generation is much greater. Losses without control are likely to be greater than for the third generation. To further complicate matters, predator populations tend to be lower and the Heliothis population tends to shift toward the hard-to-kill tobacco budworm.

Much of the fourth generation enters diapause. A fifth generation occurs in the warmer areas of the cotton belt with long growing seasons. If cotton is still lush and sprawling with warm temperatures and ample moisture from rainfall or irrigation, it may continue to be heavily infested. In such cases, the decision to make insecticide applications is based on the probabilities of successfully bringing late-season, lockable bolls. This is a function of the weather to mature the bolls
- if the crop set is at

the yield capacity of the field, the protected fruit is shed. With rain and moderate fall temperatures, succulent wild hosts become more competitive for the *Heliothis* population. Soybeans become more competitive for the fourth and fifth generations.

The above discussion with its strict adherence to a sequence of generations is over-simplified. Broods appear unexpectedly. A simple annual model with high predictability is not attainable. Careful scouting for insects and damage and plant monitoring are required throughout the fruiting period to serve as a basis for decision-making, i.e. IPM, insect pest management.

Predators and, to a lesser extent, parasites may exert excellent biological control of *Heliothis* spp. eggs and small larvae (113, 189). At best, the *Heliothis* population is unlikely to furnish adequate food to sustain a population of beneficial insects. They must be maintained by in-migration from other sources or sustained by other insect/mite populations at sub-economic levels within the field. Regulation of these by man is still in a primitive stage, but progress is being made.

Despite its limitations, biological control is usually effective on the 2d, late June, genera-

the yield capacity of the plant, the protected fruit is small. With rain and moderate fall temperatures, populations will build up and compete for the *Heliothis* population. Sometimes one more competition for the fourth and fifth generations.

The above discussion [illegible] applies to a sequence of [illegible] Brazos appear [illegible]. [illegible] with high [illegible] [illegible] for [illegible] monitoring are required through [illegible] period to serve as a basis for [illegible], i.e. IPM, insect pest management.

Predators and, [illegible] of [illegible] may exert excellent biological control of *Heliothis* [illegible] (1972). At best, the *Heliothis* population is unlikely to furnish adequate food to sustain a population of beneficial insects. They must be maintained by immigration from other sources or [illegible] insect/mite populations at sub-economic levels within the field. Research on [illegible] is still in a primitive stage, but progress is being made.

New [illegible] limitations. Biological control [illegible] effective [illegible], [illegible].

tion. This is important in that it usually greatly reduces the 3d, July, generation. Predator populations usually hold up during July. This is the key period in IPM. Assuming a good predator population, a crop that is on a good time schedule and with a high square-to-boll ratio, the scout/consultant/farmer/decision-maker will usually decide to ride with a relatively high infestation of Heliothis, as shown by field scouting. With low predator populations, maybe decimated by prior use of insecticides, a late crop or one with a low square-to-boll ratio insecticide treatment is likely to be invoked at lower infestation levels.

As usually practiced, IPM consists of getting the greatest period of usefulness from biological control. Then biological control is sacrificed and the season is finished with insecticidal control. Refinements of this system are being developed and some are in use. All insecticides at dosages effective for control of 2d stage Heliothis larvae essentially eradicate the exposed populations of beneficial insects.

Without IPM, the producers' options are to go on a schedule of insecticide applications at first bloom or to do nothing and hope for the best.

Heliothis spp. are treated here as key pests,

them. This is important in that it usually greatly reduces the [illegible] generation [illegible] Lesions usually hold up during [illegible] key worked in 1976. Assuming [illegible] lation, a stage that is on [illegible] and with high square-cut [illegible] consultant/farmer/dealer [illegible] close to [illegible] with [illegible] interest of Heliothis, as shown [illegible] now predicted [illegible] use of insecticides, [illegible] low square-to [illegible] is likely to be [illegible] lower [illegible]

As usually practiced IPM [illegible] the greatest period of usefulness [illegible] control. When biological control is [illegible] and [illegible] (Field [illegible] trol). Refinements of this system are being developed and some are in use. All [illegible] damages effectively [illegible] larvae essentially [illegible] common populations of beneficial insects.

Without IPM, the producer [illegible] on a schedule of insecticide applications at first bloom or to do nothing and hope for the best Heliothis [illegible] here [illegible]

as they are over most of the cotton belt. However, misuse of pesticides or other factors that interfere with biological control are likely to induce or intensify outbreaks. In some areas, outbreaks are largely induced, making Heliothis spp. induced rather than key pests.

Yield reduction to Heliothis spp. in the absence of control varies greatly from region to region and year to year. 1977 saw severe infestations belt-wide. 1978 was about average. 1979 was light. In some regions, logical explanations are available to explain this, but none are applicable belt-wide. Complete crop loss may well occur, but no crop loss also occurs. Pooling estimates and results of field tests from several states gives a yeild reduction in the absence of control of 45-50% (10, 58, 80, 71, 83, 130, 139, 144, 150).

Other pest species are controlled by EPN alone or in mixtures. However, EPN is not the first choice if these pests occur in the absence of Heliothis. Boll weevil infestations commonly occur concurrently with Heliothis outbreaks. The weevil is effectively controlled by EPN or, better yet, mixtures of EPN-methyl parathion. The most effective alternative insecticides as used for Heliothis are not fully effective on boll weevil and may require supplementing

as pests are [illegible] however,

[illegible] of pesticides [illegible]

with biological control [illegible]

[illegible]

[illegible], such as Heliothis spp. [illegible]

pests.

Yield reduction [illegible] Heliothis [illegible]

of control [illegible]

year to year. [illegible]

1971 was about [illegible]

regions, [illegible]

rate, but [illegible]

crop loss as well [illegible]

Pooling estimates and results of field [illegible]

several [illegible] yield [illegible]

of control of 45-[illegible] ([illegible], 80, [illegible], 1979,

146, 150).

Other pest species are controlled by [illegible]

or in mixtures. However, [illegible]

if these pests occur in the absence of [illegible]

Boll weevil infestations [illegible]

with Heliothis outbreaks. [illegible]

controlled by [illegible]

methyl parathion. The most effective [illegible]

[illegible] are not [illegible]

[illegible] are not [illegible]

with azinphosmethyl (Guthion) or methyl parathion. An estimated 10,363,850 acre applications were made for combined control of Heliothis and boll weevil in 1971 (31). In my judgment, this figure can be misleading. In most cases, Heliothis was the primary pest, but some weevils were present at sub-economic levels. EPN-methyl parathion, methyl parathion, toxaphene-methyl parathion, Penn-Cap M, and pyrethroids controlled weevils under these circumstances.

Boll weevil populations have been at a low ebb in most areas in recent years. However, uncontrolled heavy outbreaks have demonstrated many times their capability of complete crop destruction.

The plant bug complex, including the cotton fleahopper, may be present in numbers season-long. Entomologists universally agree that heavy infestations early in the fruiting season are important. The damage from mid- and late-season infestations, when EPN would be used in an IPM program, is an area in which entomologists do not agree. EPN is effective in controlling this pest complex. It is not first choice for early season control, but does a superb job in mid- and late-season on plant bugs when it is used for Heliothis control.

Spider mites are induced pests of cotton when insecticides are used that destroy their natural enemies without killing the mites. Carbaryl is a no-

with predominantly (inadequate) [illegible]

An estimated 10,[illegible] acre applications were [illegible]

for combined control of H. zea and boll weevil [illegible]

1971 [illegible]. In my judgment, this [illegible]

leading. In most cases, Heliothis was the [illegible]

pest, but some weevils were present [illegible]

levels. EPN-methyl parathion, methyl parathion, [illegible]

[illegible]-methyl, parathion, [illegible]

controlled weevils under these circumstances.

Boll weevil populations have been [illegible]

most areas in recent years. However, [illegible]

heavy outbreaks have demonstrated [illegible]

capability of complete crop [illegible]

The plant bug complex. [illegible]

however, Lygus present in [illegible]

[illegible] are universally [illegible]

early in the fruiting season [illegible]

from mid- and late-season infestations. [illegible]

be used in an IPM program, is an area [illegible]

molecules do not exist. [illegible] is effective [illegible]

this pest complex. It is not [illegible]

season control, but [illegible]

season on plant bugs when it is used for [illegible]

trol.

Spider mites are favored [illegible] of certain [illegible]

insecticides are used that destroy their natural

enemies without killing the mites. [illegible]

torious mite-builder and the synthetic pyrethroids are gaining a similar reputation[1]. While EPN is not recommended for control of heavy established infestations, mite outbreaks are not induced by regular use of EPN and EPN mixtures. Yields were reduced 45% and lint and seed quality adversely affected from a seasonal average infestation of 10.88 mites sq./in. compared to cotton with a seasonal average infestation of 0.91/sq.in. (140). Infestations of this magnitude were not uncommon following a heavy schedule of chlorinated hydrocarbon insecticides used without a mite suppressant added.

Pink bollworm is readily controlled by EPN. Several other insecticides are effective and more commonly used. However, when used for *Heliothis* control, EPN alone or in mixtures does an excellent job on pink bollworm. Pink bollworm is a serious problem in the desert valleys of the far west, Arizona, and southern California (181). In similar producing areas with full season production and without cultural-mechanical controls, complete crop loss ordinarily occurs from pink bollworm. Use of cultural-mechanical controls in Arizona and southern California have reduced the problem to manageable proportions with heavy use of insecticides. The problem could be essentially controlled without

---

[1] Prior to introduction of DDT and other chlorinated hydrocarbon insecticides, spider mites were not recognized as cotton pests anywhere in the cotton belt except as very local infestations in Northeastern Arkansas. When the chlorinated hydrocarbons came into wide usage, mites became a problem belt-wide. Destruction of predatory insects and mites was the major cause of this change. Apparently, DDT also compounded the problem by causing a behavioral change that caused mites to move about and infest the plants more completely.

[illegible] the [illegible]
[illegible] a small [illegible] [1] [illegible]
needed for control [illegible] heavy [illegible] cotton, [illegible]
[illegible] not [illegible]
[illegible]
adversely affected [illegible]
10.83 miles sq [illegible] cotton [illegible]
average infestation [illegible]
this magnitude [illegible]
[illegible]
supplement added [illegible]

Pink bollworm [illegible]
other insecticides are [illegible]
However, [illegible]
[illegible] excellent [illegible]
bollworm is a serious [illegible]
far west, Arizona, and southern [illegible]
producing [illegible]
cultural-mechanical controls, [illegible]
[illegible] pink bollworm. [illegible]
trols in Arizona and southern [illegible]
problem to [illegible]
[illegible]

[1] [illegible]

insecticides by early crop termination, as practiced in the Lower Rio Grande Valley. The consequent yield reductions have so far proven unacceptable to growers.

Fall armyworm does not diapause. It remains active over winter in the extreme southern states. Depending on weather, biological control, and other factors, northernly migrations occur. About one year out of ten, damaging infestations develop widely in cotton in Arkansas. The frequency of damaging infestations may be greater or lesser in other cotton-producing areas. Fall armyworm has a broad host range with a preference for grasses. On cotton, it is more of a leaf-feeder than Heliothis spp., but squares and bolls are heavily damaged, as much as 50% yield reduction, by large infestations. EPN and EPN mixtures give effective control. When outbreaks occur, they tend to be concurrent with Heliothis outbreaks (8).

The beet armyworm and the yellow-striped armyworm are occasionally destructive pests of cotton, feeding on fruit as well as foliage. Heavy infestations cause damage of similar magnitude to that of fall armyworm. Little is known about causes of outbreaks other than that they are commonly associated with weedy fields. EPN alone or in

---

Many organophosphorus insecticides were highly effective for mite control. As they replaced the chlorinated hydrocarbons because of resistance to the chlorinated hydrocarbons first in boll weevil and then in Heliothis, mite control became excellent. Mites have a great genetic capacity for developing resistance to miticides (insecticides). EPN-methyl parathion can no longer be depended on for a knock-out of established infestations, but its use rarely, if ever, induces mite outbreaks.

[illegible] control [illegible]

[illegible]

[illegible] field [illegible]

[illegible] and predators. An insecticide [illegible] these beneficial [illegible] to develop that lead to [illegible] from the [illegible] further complicated by growth [illegible] In extreme cases, [illegible] reduced. Use of [illegible] and [illegible] controls the cotton [illegible] recommended for *Heliothis* [illegible] exists for whiteflies except [illegible] and possibly elsewhere, [illegible] methyl parathion and most [illegible] acephate and methidathion.

Application of [illegible] parathion [illegible] yields independent of insect control. [illegible] in northeastern Arkansas. [illegible] function of keeping the crop [illegible]

[illegible] under controlled field conditions [illegible] on the [illegible] are [illegible] of field observations following their use in [illegible] fashions.

[illegible] available to clean out established [illegible] (Imidan) or methidathion (Supracide) [illegible]

mixtures gives good control, as do several other insecticides (8).

The cotton aphid is normally held in check by parasites and predators. An insecticide application that destroys these beneficial insects permits heavy infestations to develop that lead to defoliation and to staining of the lint from the sticky honeydew that aphids excrete. This is further complicated by growth of black, sooty mold on the honeydew. In extreme cases, yield and quality are severely reduced. Use of EPN and EPN mixtures for Heliothis effectively controls the cotton aphid, as do most other insecticides recommended for Heliothis control. A similar situation exists for whiteflies except that in some areas in Louisiana and possibly elsewhere, whiteflies are resistant to EPN, methyl parathion and most other insecticides except monocrotophos and methadithion.

Application of EPN-methyl parathion increases cotton yields independent of insect control. This is true at least in southeastern Arkansas. This yield-increasing effect is not a function of making the crop earlier or later (90).

Establishing and maintaining spider mite infestations experimentally under controlled field conditions borders on the impossible. Insecticides are classified as mite suppressants or mite builders on the basis of a large number of field observations following their use in repeated applications.

Miticides are available to clean out established or incipient infestations. If insect problems exist concurrently, monocrotophos (Azodrin) or methadithion (Supracide) are favored because they are also broad spectrum insecticides.

mixtures gives good control, as [illegible] several other insecticide[illegible]

The cotton aphid is normally held in check by parasites [illegible] predators. An increase in the application that destroys these beneficial insect [illegible] heavy infestations to develop that lead to defoliation and [illegible] staining of the lint from the sticky honeydew that aphids excrete. This is further complicated by growth of [illegible] sooty mold [illegible] honeydew. In extreme cases, yield [illegible] quality are [illegible] reduced. Use [illegible] EPN [illegible] mixture [illegible] effectively control the cotton aphid, as [illegible] other insecticides recommended for [illegible] cotton [illegible]. A similar situation exists for whitefl[illegible] [illegible] that in some areas [illegible] and possibly elsewhere, [illegible] mixture [illegible] methyl parathion and most other insecticides except [illegible] crotophos and [illegible]

Application of EPN-[illegible] [illegible] to cotton [illegible] yields independent of insect control. This is true at least in southeastern Arkansas. This [illegible] not a function of making [illegible] later [illegible].

Establishing and maintaining [illegible] experimentally under controlled field [illegible] impossible. Insect [illegible] classified as mite [illegible] or mite builders on the basis of [illegible] of [illegible] following their use [illegible] applied [illegible]

Mites [illegible] available [illegible] clean [illegible] established [illegible] [illegible] infestation [illegible] some [illegible] economic [illegible] [illegible] cotton [illegible] broad spectrum insecti-

3. Use of Pesticide in Producing Commodity

Some EPN, mostly as a 1:1 ratio with methyl parathion, has been used on cotton since the 1960's. It moved to the forefront in 1976 when 6,140,000 pounds of EPN was used on U.S. cotton (42). Six million pounds used at 0.5 to 0.75 pounds a.i./A. with an equal amount of methyl parathion will treat eight to 12 million acres at one time. This is approximately 0.8 applications per acre of cotton grown in the U.S. Later figures than 1976 can only be approximated. Its use probably increased in 1977, dropped to the 1976 level in 1978, and dropped considerably in 1979 - in response to the ups and downs of *Heliothis* infestations and availability of pyrethroids and sulprofos (Bolstar).

EPN, usually in mixtures, is heavily used in South Carolina, Georgia, Alabama, Tennessee, Mississippi, Louisiana, Arkansas, and Texas (10,29,58,71,83,109,130,139,150). Its use in Arizona and Southern California depends on the highly variable tobacco budworm populations, from more than 230,000 pounds in each state in 1977 to very little in 1979 (163,181). Arizona used 92,100 pounds in 1978.

South Carolina:	3-12 applications on most of their 150,000 acres
Alabama:	800,000 acre applications on 300,000 acres of cotton
Tennessee:	1 or more applications to 75,000 acres
Mississippi:	two pounds/A on 1 to 1.7 million acres, not uniformly distributed
Louisiana:	465,000 acres treated 2-6 times, average of 3, all in late season
Arkansas:	300,000 acres treated 2 to 8 times

Texas is a major user of EPN, but good estimates are not available.

North Carolina, Missouri, Oklahoma, and New Mexico use little EPN.

The principal formulation is 3:3, three pounds each of EPN and methyl parathion per gallon of emulsifiable concentrate. Other formulations, although registered, are little used and this discussion is based on use of the 3:3 formulation. A 2:4 formulation is registered. It is less effective on Heliothis, but is somewhat cheaper. EPN is also available as a five, four, and two pound per gallon E.C. and in a mixture with toxaphene-methyl parathion-EPN 4+3+1, toxaphene-EPN 6+2, and EPN-Guthion 2+1 pounds per gallon E.C.

EPN formulations are packaged in five gallon metal cans and 30 and 55 gallon metal drums.

The cost to the grower for EPN-methyl parathion to be applied at 0.5 + 0.5 pounds per acre is approximately $3.00. Alternative larvicides are in the $5.00-$7.00 range (10,109). These figures do not include cost of application.

Ovicides are used at low rates, making them economical for an application. However, applications must be repeated frequently or else the ovicides must be used to supplement larvicides. They are supplements and not competitors of larvicides.

Chlordimeform (Galecron and Fundal) is a Heliothis ovicide at dosages of one-eighth to one-fourth pound a.i./A. Impact on beneficial insects is minimal. Methomyl (Lannate and Nudrin) is a Heliothis ovicide at one-eighth a.i./A. Several others are being researched as ovicides. Some of

North Carolina, [illegible], and New York use

lindane.

The potential formulation is 31$\frac{1}{2}$, three pounds each of DDT and methyl parathion per [illegible] of [illegible] concentrate. [illegible] used and this dimension [illegible] tion. A [illegible] formulation [illegible] on [illegible] as [illegible] [illegible] ture with toxaphene-methyl parathion [illegible] 6+2, and [illegible] [illegible] pounds [illegible]

[illegible]

and 30 and [illegible] [illegible]

[illegible]

applied [illegible] 0.5 + 0.5 pound per acre [illegible]

Alternative larvicides are in the [illegible] (77,[illegible]).

These figures do not include cost of application.

Ovicides are [illegible] of low value, making them uneconomical for [illegible] application. However, applications must be [illegible] frequently or else the ovicides must be used to supplement larvicides. They are supplements and not [illegible] larvicides.

[illegible] (Quaintance and [illegible]) [illegible] [illegible] of [illegible] [illegible] pound [illegible] [illegible] [illegible] [illegible] [illegible]

them become effective larvicides at higher dosages than those used as ovicides. With the low dosages required for ovicidal effectiveness, beneficial insect populations are not drastically reduced. With very good IPM practice, it is possible to sufficiently reduce populations by a combination of ovicidal action and natural predator kill to keep a Heliothis population below damaging levels. This is harmonious use of insecticides (ovicides) and biocontrol concurrently. If this approach fails and damaging larval populations break through, there is still time to use a larvicide. The principal limitation of this approach lies in the difficulty of finding Heliothis eggs and getting a good estimate of their abundance. There is a threat that this will be met by scheduled use of ovicides, a giant step backward for IPM.

The alternative larvicides are not proven ovicides with the exception of methomyl. Further evaluations are needed on Orthene and Bolstar. By adding an ovicidal dosage of chlordimeform or methomyl to the Heliothis larvicide, kill of eggs as well as larvae is obtained. This makes possible stretching the interval between applications by obtaining both larval and egg kill, i.e. the ovicide supplements the larvicide.

Application of Heliothis larvicides is by foliar spray in mid-late season. At least 80% or more is custom applied aerially. The remaining less than 20% is applied with ground machinery, usually by the individual farmer, but with some custom work (10,71,83,109,130,139,150).

The base application rate is 0.5 + 0.5 lb. a. i./A of EPN-methyl parathion. If infestation pressure dictates, this

than become effective larvicides at higher dosages than those used as ovicides. With the low dosages required for ovicidal effectiveness, beneficial insect populations are not drastically reduced. With very good IPM practice, it is possible to sufficiently reduce populations by a combination of ovicidal action and natural predator [illegible] to keep Heliothis from attaining damaging levels. This is harmonious use of [illegible] (ovicides) and biocontrol concurrently. [illegible] fails and damaging larval populations build up [illegible] there is still time to use a larvicide. The principal limitation of this approach lies in the difficulty of finding the small eggs and getting good estimates of their abundance. It is apparent that this will [illegible] scheduled use of ovicides, a giant step backward for IPM.

The alternative larvicides are [illegible] with the exception of methomyl. Further [illegible] on Orthene and Galecron. By adding [illegible] ovicidal dosage of chlordimeform or methomyl to the Heliothis larvicide [illegible] of eggs as well as larvae [illegible]. This [illegible] possible stretching the interval between applications [illegible] both larval and egg kill, i.e. the ovicide supplements the larvicide.

[illegible] Application of Heliothis larvicides [illegible] in [illegible] season. At least [illegible] [illegible] resulting less than [illegible] is applied with [illegible], mostly in the [illegible] [illegible] (10,21,83,109,170, [illegible]).

[illegible] application rate is 0.5 to 2.0 lb. a.i. [illegible] [illegible] on [illegible]

rate may be increased to 0.67 to 0.75 or occasionally, to one pound each. Alternatively, tank-mixing with an ovicide (chlordimeform or methomyl) or with chlorpyrifos for increased larvicidal activity may be practiced. Even with the increased rates or mixtures, the price is cost-competitive with effective alternative insecticides.

Given continuing pressure, the usual interval between applications is five days. Most treatment decisions are made on the basis of field scouting, using the best IPM techniques presently available. This often permits stretching intervals or skipping applications entirely. Depending on continuing severity of the problem, the number of applications varies from one to 20. Twenty applications is very high. Usually, this would be by a grower who goes on schedule and does not scout or have this cotton scouted. Occasionally, an outbreak will get out of hand and this compounded by frequent rains that wash off the insecticide will call for short intervals between applications. I know of no way to obtain an accurate estimate of the average number of applications for Heliothis control with all insecticides.

For aerial application, water is used as the diluent with application rates of one to three gallons per acre. Tanks are metal with 100-300 gallons capacity, depending on the type of airplane. Hollow cone nozzles are spaced on a boom to give even swath distribution. Nozzle pressure is in the 40-60 p.s.i. range. There is a strong trend to using a closed mixing system with the finished spray pumped into

rate may be increased to 0.25 to 0.75 of a commodity, to the pound each. Alternatively, [illegible] with an ovicide (chlordimeform or methomyl) or with compounds for their larvicidal activity may be prolonged. Even with the increased rates or mixtures, the price is cost competitive with alternative insecticides.

Given continuing pressure [illegible] interval between applications [illegible] on the basis of field practice, [illegible] presently available. This [illegible] applications [illegible] severity of the problem, the [illegible] from one to 20. [illegible] this would be [illegible] scout or have [illegible] will [illegible] that wash off [illegible] between spray [illegible] estimate of the average number of applications for [illegible] control with all insecticides.

For aerial application, [illegible] with application rates of [illegible] three gallons per [illegible] Tanks are metal with 100-300 gallon capacity, depending on the type of airplane. Hollow cone nozzles are spaced on a boom to give even swath distribution. [illegible] pressure [illegible] 40-60 p.s.i. range. There [illegible] [illegible] with the finished spray [illegible]

the tank. However, some open systems are used, especially when operating from satellite fields. Cabs are closed. Two or three loaders are commonly used. Human flaggers are seldom used. When they are, they are usually well protected by umbrellas and protective clothing. Once the plane is lined up for its run, the flagger moves over a swath width, 40 or more feet. If there is a cross breeze or wind, spraying moves up-wind, offering further protection to flaggers. Fixed or permanent flags are more commonly used. Or two planes fly the buddy system. Each plane uses the swath of its buddy as a swath marker and spraying moves up the cross wind or breeze. Some optimists fly singly without markers or flags, but this too often results in poor control in un-sprayed skips. One-hundred acres per hour can be treated if ferry distance is short, loading efficient, and fields large.

For ground application, eight or 12 row equipment is used with 150-300 gallon metal tanks. Hollow cone nozzles are used, either with one over the row and a drop nozzle directed down and in on each side of the row or with nozzles evenly spaced 19-20 inches apart on the boom and directed down. Nozzle pressure is 40-60 p.s.i. Rates are five to ten gallons per acre with water as the carrier.

In one type of operation, one man serves as both driver and loader. After spraying out a tank, he returns to the water/insecticide source and refills. The insecticide is

the tank. However, some [illegible] used, especially when operating from gasoline [illegible]

Two or three loaders are [illegible] used. [illegible] are seldom used. [illegible] usually well [illegible] by [illegible] d [illegible] [illegible] is lined up for its [illegible] 40 or more feet. [illegible] move up-wind, either [illegible] flared at [illegible] planes [illegible] the [illegible] as a swath marker and [illegible] wind or [illegible] or flags, but [illegible] too often [illegible] operated [illegible] hand-held [illegible] if ferry distance is short [illegible] length.

For ground application, [illegible] used with 150-300 gallon [illegible] are used, [illegible] directed down and [illegible] on each side [illegible] evenly spaced 18-20 inches apart on the [illegible] down. Nozzle pressure is [illegible] ten gallons per acre with [illegible] the carrier.

In [illegible] of [illegible] and loader. After spraying [illegible] [illegible] and [illegible] the [illegible]

usually poured into the tank from five gallon cans while the tank is filling. The motor is running to provide by-pass agitation to insure mixing.

In another type of operation, a nurse tank is delivered to the site. In a nurse tank operation, more than one sprayer may operate from the same nurse tank. Use of a nurse tank reduces travel time of the sprayers. In a nurse tank operation, the water and insecticide may be mixed at the central water source with the insecticide poured into the nurse tank from five gallon cans or pumped from 30 or 55 gallon drums. The nurse tanks must be equipped with agitation for uniform mixing. Alternatively, the insecticide is taken to the field along with the nurse tank and filled as described in the preceding paragraph. A nurse tank/ground sprayer operation requires one full- and one part-time worker for one sprayer. Four workers can operate three sprayers and a nurse tank.

Almost all sprayers have no cab. The driver is seated ahead and above the boom. There is essentially no exposure to the insecticide except in loading. Exposure in loading depends on precautions taken and the mixing procedure. The safest procedure is to use a nurse tank equipped with agitation and with the insecticide pumped into the nurse tank while it is filling. The mixed spray is then pumped into the sprayers as needed.

With long rows, a 12-row sprayer can cover 30 acres an hour while actually spraying. Considering shorter rows,

usually pumped into the tank from five gallon cans while the tank is filling. The motor is running to provide [illegible] agitation to insure mixing.

In another type of operation, a nurse tank is delivered to the [illegible]. In a nurse tank operation, more than one sprayer may operate from the same nurse tank. [illegible] reduces travel [illegible] of the sprayer[illegible]. [illegible] them, the water and insecticide [illegible] mixed [illegible] water comes with the insecticide [illegible] into the nurse tank from five gallon cans or pumped from [illegible] drums. The nurse tank must be equipped with [illegible] uniform mixing. An example [illegible] insecticide [illegible] to the field along with the nurse tank and filled [illegible] described in the preceding paragraph. A nurse tank [illegible] operation requires one full- and one part-time worker [illegible] the sprayer. [illegible] workers can operate three sprayers and nurse tank.

Almost all sprayers have no cab. The driver is [illegible] ahead and above the boom. There is practically no exposure to the insecticide except in loading. Exposure in loading depends on precautions taken and the mixing procedure. The safest procedure is to use a nurse tank equipped with agitation and with the insecticide pumped into the nurse tank while it is filling. The mixed spray is then pumped into the sprayers as needed.

With [illegible] a [illegible] sprayer can cover 30 acres an [illegible] [illegible] sprayer 7000.

smaller fields, road and mixing time, nozzle stoppages and routine maintenance, 15 acres per hour with 12-row and ten acres per hour with eight row equipment is easily attainable, but probably above average.

4. Precautionary Measures

Required by label: clean, natural rubber gloves; clean waterproof clothing; rubber boots; goggles; mask or respirator passed by the U.S. Bureau of Mines for methyl parathion and EPN protection.

Normally used: waterproof clothing prevents perspiration from evaporating. Its use is sheer suicide in the hot southern sun. A mask or respirator may become contaminated when not in use, making it very hazardous to wear. The workers comply as best they can, but survival comes first. Normal wear consists of rubber gloves, hat or cap, tightly-woven coveralls and leather boots or shoes in good condition (8,10).

Preharvest and re-entry intervals: Do not handpick or harvest within three days is always observed and with a considerable margin. The re-entry period is 24 hours for EPN and 48 hours for methyl parathion and then only when foliage is dry. Since EPN is almost always applied in mixtures with methyl parathion, a 48 hour re-entry period for EPN, as suggested by team member George Ware, would cause no hardship. The 24 hour re-entry period is always observed. Exceptions to the 48 hour re-entry period occur occasionally when scouts fail to get the treatment information. This communication problem is difficult to completely

smaller fields, road and mining [illegible]

routine maintenance, [illegible]

acres per hour [illegible]

but probably [illegible]

4. Precautionary [illegible]

Recommended by label: [illegible] rubber gloves [illegible]

waterproof clothing; rubber boots; [illegible]

passed by the U.S. Bureau of Mines for [illegible]

EPN protection.

Normally used: Water-proof clothing [illegible]

from evaporation. [illegible]

southern sun. [illegible]

when not in use, makes it [illegible]

workers supply [illegible]

Normal wear consists of rubber gloves, [illegible]

wear, coveralls and leather boots [illegible]

(4,10).

Treatment and results: [illegible]

or harvest within three [illegible]

considerable margin. The re-entry period [illegible]

EPN and 48 hours for methyl [illegible]

foliage is dry. Since EPN is almost always applied in

mixtures with methyl parathion, [illegible]

to [illegible] by [illegible] would

no hardship. The 48 hour re-entry period is always

observed [illegible] exceptions to the 48 hour re-entry period occur

[illegible] fail to get the treatment into [illegible]

overcome with farmers, aerial applicators, and scouts all operating over wide-ranging areas. Treatment is usually made the same or following day after scouts recommend treatment. This automatically minimizes risk of violating the re-entry period.

Post-Pesticide Treatment Activities:

Scouting: Once or twice weekly, two or more days after treatment, 40 acres per hour.

Irrigation: Intervals may be as short as ten days or there may be no irrigation. Irrigation normally does not require field entry. Time varies with equipment and water supply.

Harvesting: 30 or more days after treatment, two acres/hr. with two row spindle picker.

5. Exposure and Hazards

Minimal exposure and no known hazards from use of EPN.

Alabama:	Cholinesterase monitoring of 20-25 cotton scouts for the three year period 1972-4 indicates no health hazard (150).
Arkansas:	No known problems. Two studies have shown no cholinesterase inhibition among scouts and loaders and only one for a grossly careless pilot. Since EPN is always used in mixture with methyl parathion, this is strong evidence of no exposure hazard unless there is gross negligence (10).
Georgia:	No known problems (83).
Louisiana:	No known cases of injury or intoxication (139).
South Carolina:	The Medical University of South Carolina Charleston, shows no reported cases of EPN poisoning from 1967 to 1979 (71). Records were not kept prior to 1967.

[illegible] with [illegible], [illegible] and [illegible] all

operating over [illegible] areas. Treatment is usually

made the same or following day after [illegible]

ment. This [illegible] the risk of [illegible]

[illegible] period.

Post-Harvest Treatment [illegible]

Scouting: Once or twice weekly [illegible]

[illegible]ment, [illegible] acres per [illegible].

Irrigation: Intervals may be [illegible]

may be no irrigation. Irrigation [illegible] requires

field entry. Time varies with [illegible]

Harvesting: [illegible]

with two row [illegible].

5. Exposure and Hazards

Minimal exposure and no known hazards from use of [illegible]

Aldrin: [illegible]

Arthropods: [illegible] problems. Two studies [illegible] shown [illegible] given [illegible] a crop [illegible] used to [illegible] or, [illegible] is [illegible]

[illegible] (1963).

No known cases of [illegible].

Potential [illegible]

6. Role of RPARd Insecticide

State recommendations for control of bollworm and tobacco budworm:

Alabama:	¼ + ¼ to 3/4 + 3/4 pounds EPN and methyl parathion per acre (150)
Arkansas:	½ + ½ to 3/4 + 3/4 (10)
Georgia:	½ + ½ (83)
Louisiana:	½ + ½ to 1 + 1 (139)
Mississippi:	½ + ½ to 3/4 + 3/4 (109)
South Carolina:	½ + ½ to 1 + 1 (71)
Tennessee:	3/4 + 3/4 (130)

For bollweevil control in the absence of bollworms and budworms, the usual dosage is ¼ + ¼ pounds EPN + methyl parathion per acre.

Pest management programs are widely used throughout the Cotton Belt. The standard procedure is to scout the cotton once or twice weekly. As long as pest infestations are at sub-economic levels and/or biological control is adequate, no insecticides are applied.

Alabama:	90% of the acreage is under IPM and the remainder is strongly influenced by the program. Applications are seldom made before mid or late July (150).
Arkansas:	95% of the acreage is under IPM. Treatment seldom begins before mid-July. Each field is scouted and treatment begins when action levels are reached. Community-wide programs are being activated. Managing pest populations community-wide is proving much more efficient with 80% reduction in insecticide inputs compared to treatment of individual fields (10,132).

Louisiana: 80% of acreage under supervision of consultants. Treat only after economic threshold is reached (139).

South Carolina: Seldom treat before mid-July. 75% participation in identifiable IPM programs with rest strongly influenced (71).

Tennessee: IPM programs in operation since 1972. Present identifiable participation is 10-12% (130).

Texas has so many different agroecosystems with cotton that generalizations are difficult. The 2.5 million acres on the High Plains seldom require insecticide treatment. However, in recent years, *Heliothis* is emerging as a problem and IPM programs are being instituted to cope with it. In the rest of Texas, 1.7 million acres is under IPM (144). In the Brazos Valley, the program is mainly scout and treat as needed. In other areas, programs have become much more refined. In the Rolling Plains, delayed planting community-wide results in suicidal emergence of boll weevil; without need for insecticidal treatment for boll weevil, *Heliothis* is seldom a problem. In most of the rest of Texas, production of MAR varieties gives sufficient earliness to greatly reduce insecticide use with competitive or increased yields.

In Arizona and Southern California, pink bollworm can be managed in a manner that reduces dependence on insecticides, avoiding induction of the tobacco budworm problem (181).

The National Cotton Council estimates that 37% of the cotton acreage is under IPM. If the 2.5 million acres on the High Plains with a very low insect hazard are excluded, the figure jumps to 47% (144).

Louisiana:	80% of acreage under supervision of consultants. [illegible] only when economic threshold is reached (1971)
South Carolina:	[illegible] blum boll weevil [illegible] participation in identified [illegible] pests [illegible] (1971)
Tennessee:	IPM programs in operation since 19[illegible]. Present [illegible] participation [illegible] (1970).

Texas has so many [illegible] that generalizations are difficult. [illegible] million acres on the High Plains seldom require insecticide [illegible] However, [illegible] and IPM programs are being [illegible] the rest of Texas [illegible] million [illegible] In the Brazos Valley, the program [illegible] as needed. In [illegible] areas, [illegible] refined. In the Rolling Plains, [illegible] wide results in substantial [illegible] of boll weevil [illegible] need for insecticidal treatment for boll weevil. [illegible] is seldom a problem. In [illegible] of the [illegible] Texas, [illegible] tion of [illegible] varieties [illegible] reduce insecticide use with [illegible] yield.

In Arizona and Southern California, pink bollworm [illegible] aged in a manner that reduced [illegible] [illegible] of the tobacco budworm problem (1971).

The National Cotton Council [illegible] estimates that 37% of the [illegible] under IPM. If the 2.5 million acres on the [illegible] are excluded, the [illegible]

7. Other Registered Pesticides

This will be limited to *Heliothis* larvicides. Ovicides and biological insecticides have a place in *Heliothis* management and are being used more and more, but they are supplements to and not substitutes for larvicides.

If an alternative insecticide for *Heliothis* control is ineffective on boll weevil, mites, or other pests that occur concurrently with *Heliothis* outbreaks, additional costs are incurred by the necessity of adding other insecticides to the mix or making special applications.

The pyrethroids - permethrin (Ambush, Pounce) and fenvalerate (Pydrin) are more expensive than EPN-methyl parathion. They may be sufficiently more effective on *Heliothis* to require fewer applications, partially offsetting increased cost. With longer intervals between applications, heavy infestations of weevils are not adequately controlled. The pyrethroids are developing reputations as mite-builders[1/].

Acephate (Orthene) is expensive. It is somewhat weak as a one-time knockdown on *Heliothis* and performs better on a schedule of successive applications. It is not effective on weevils.

Sulprofos (Bolstar) is quite effective on *Heliothis*, but is expensive. It is not effective on boll weevil.

Chlorpyrifos (Lorsban) is expensive and probably less effective on *Heliothis* than EPN-methyl parathion, the pyrethroids, and Bolstar. It seems to do better as an

additive rather than as the primary insecticide for Heliothis.

Monocrotophos (Azodrin) is more expensive than EPN-methyl parathion. It is less effective than EPN-methyl parathion, the pyrethroids, and Bolstar unless very high and expensive rates are used.

Methyl parathion alone is less effective, especially on tobacco budworm than other recommended insecticides with the possible exception of carbaryl.

Encapsulated methyl parathion (Penncap M) is more expensive than EPN-methyl parathion.

Methyl parathion + toxaphene is not very effective on many populations of tobacco budworm. Toxaphene is also being RPARd.

Carbaryl (Sevin) is not as effective on Heliothis and weevil as EPN-methyl parathion and is a mite-builder[1/].

Methomyl (Lannate, Nudrin) is effective on Heliothis, but at the high dosages and heavy schedules required for severe, long-running Heliothis outbreaks, leaf-reddening becomes severe with possible yield reduction from phytotoxicity. It is not effective on boll weevil.

Of the 13 registered alternative insecticides, brand names and mixtures EPN-methyl parathion is considered more effective for Heliothis control than six, equal to four, and possibly not quite as effective as the three synthetic pyrethroids. To fully equal the pyrethroids, the dosage may be raised to 0.75 each of EPN-methyl parathion, the mixture spiked with chlorpyrifos (Lorsban), or the interval between

applications shortened. Yields would be the same from use of EPN-methyl parathion and the seven effective alternative insecticides, given good pest management practices.

Cost of application is the same for EPN-methyl parathion and all the alternatives.

All of these alternatives are of value in a good IPM system in that the insecticide best suited for a given situation can be selected. With a diversity of available insecticides, resistance to any of them can be delayed.

Cost per Acre Application for Heliothis Control
Exclusive of Application Costs (modified from 109)

Insecticide	Rate/acre lbs a.i.	Cost
Acephate (Orthene)	1	$7.93
permethrin (Ambush)	0.1	6.40
permethrin (Pounce)	0.1	5.78
sulprofos (Bolstar)	1	6.66
chlorpyrifos (Lorsban)	1	6.52
Curacron	1	7.50
EPN + methyl parathion	0.5 + 0.5	3.00
Monocrotophos (Azodrin)	1	5.10
fenvalerate (Pydrin)	0.1	5.85
toxaphene + methyl parathion	2 + 1	3.38
Carbaryl (Sevin)	1.6	3.49
Methomyl (Lannate)	0.45	4.48
Methomyl (Nudrin)	0.45	4.48
methyl parathion	1	1.68
Penn-Cap M	1	N.A.

Summary and Conclusion

EPN in mixture with methyl parathion is the most cost effective insecticide treatment for Heliothis spp., bollworm and tobacco budworm, on cotton over most of the Cotton Belt. When used for Heliothis, it also controls or suppresses such other pests as boll weevil, plant bugs and fleahoppers, spider mites, pink bollworm, fall armyworm, beet armyworm, yellow-striped armyworm, cotton aphid, and usually whiteflies.

EPN has a long history of safe use on cotton without detectable hazard to those who work with it, given normal safety procedures. EPN-methyl para-

thion 3-3 E.C. mixes readily with ovicides. It can also be "spiked" to give a three-way mixture to use in cases of extreme larval pressure, especially large tobacco budworms. EPN and EPN mixtures fit readily into use in customary mixing and application equipment.

Alternative insecticides that are as effective or possibly slightly more effective for *Heliothis* control are ineffective on boll weevil.

Insects Take Nearly 9 Percent Of 1979 Cotton Production

By Dr. Jim Hamer
Mississippi Extension Pest Management Specialist

MISSISSIPPI STATE, Miss. — Damaging insect populations were remarkably low in cotton last season. But how significant was loss in yield from these insect pests?

Table 1: Yield Loss From Cotton Insects For The Cotton Belt

Loss Attributed To	Number Bales Lost	Percent Loss (Average)
Boll Weevil	208,790	1.4
Bollworm-Tobacco Budworm	441,920	3.0
Cotton Fleahopper	211,300	1.4
Lygus spp. and other Plant Bugs	208,730	1.4
Cotton Leaf Perforator	0	0
Pink Bollworm	3,380	0
Spider Mite	108,000	0.7
Thrips	37,950	0.3
Others [1]	87,040	0.6
Total	1,307,110	8.8

[1] Fall armyworm, European corn borer, cotton aphid, Euschistus spp., and cotton leafworm.

Much better loss estimates will be available in the future in cotton as a result of action taken in the 1979 Cotton Insect Research and Control Conference in which the conferees (under the guidance of Charlie Parencia) voted in favor of an insect loss estimate study in cotton.

In implementing this study, a losses estimate committee (with one member from each state engaged in the production of cotton) was selected by a chairman approved by the conferees.

Each committee member served as a state coordinator with his responsibility being to secure losses data from a state committee named by him. Individual state results were compiled, summarized, and presented at the 1980 Cotton Insect Research and Control Conference in St. Louis, Mo.

Significance

The significance of an annual loss estimate for insect damage in cotton was recognized and endorsed by the conference as one on-going aspect of the conference. The results are presented in the accompanying tables.

Table 2: Total Percent Loss And Bale Loss In Cotton For States From Insect Damage

State	Total Percent Lost	Total Bales Lost
Alabama	23.00	73,600
Arizona	0.65	8,780
Arkansas	4.00	24,400
California	5.94	200,770
Florida	16.50	580
Georgia	31.36	48,610
Louisiana	8.00	55,200
Mississippi	13.94	202,130
Missouri	17.00	27,000
New Mexico	8.50	8,920
North Carolina	6.47	2,350
Oklahoma	7.00	36,400
South Carolina	16.00	18,400
Tennessee	8.50	14,620
Texas	10.26	584,820
Virginia	6.00	7,000

e 3. Estimated Reduction In 1979 Cotton Yields Resulting From Insect Damage[1]

Loss tribuiable to	Arkansas	Louisiana	State Mississippi	Missouri	Tennessee
·evil:					
ıt	0.5	4.0	3.16	0	0
....	3.05	27.6	45.82	0	0
rm-tobacco ɔrm:					
ent	1.0	2.0	3.35	3.0	1.0
s..	6.1	13.8	48.53	4.77	1.72
fleahopper:					
nt	1.0	1.0	0.16	2.0	NA
....	6.1	6.9	2.32	3.18	NA
spp. and plant bugs:					
ent	1.0	1.0	4.19	9.0	5.0
,	6.1	6.9	60.75	14.31	8.6
leaf ·ator:					
ent	0	0	NA	NA	NA
s...............	0	0	NA	NA	NA
ollworm:					
·nt	0	0	NA	NA	NA
....	0	0	NA	NA	NA
mite, nychus spp.:					
ent	0.5	0	0.19	1.0	0.5
s...............	3.05	0	2.75	1.59	0.86
, kiniella spp.:					
ent	0	0	1.13	1.0	1.0
s...............	0	0	16.38	1.59	1.72
s:					
ent	0	0	1.76[2]	1.0[3]	1.0[4]
....	0	0	25.52	1.59	1.72
percent loss	4.0	8.0	13.94	17.0	8.5
bales lost	24.4	55.2	202.13	27.0	14.62
n bales [5]........	610	690	11,450	159	172

of control which helped hold losses to indicated level not estimated; all figures in table) except percent. NA, not applicable.
armyworm (Spodoptera frugiperda (J.E. Smith).
pean corn borer (Ostrinia nubilalia (Hubner).
n aphid (Aphis gossypii Glover).
mated by research, extension, and others based on Statistical Reporting Service t.

Fri

SECTION 2 - SOYBEANS

1. ... soybeans were grown on ... in the U.S. in 1979, producing 2.267 ... million bushels ... worth ... $13.8 billion (41). The ... average yield ... bu/acre. Soybean production is ... western and northern ... are planted ... annually produce ... double-cropping system, the soybean-corn ... cotton-small grain, soybean ... the South. Soybean grain is an important commodity.

2. ... pests of soybeans ... in ... states which account for ... in the United States. Despite the relative ... of soybeans, the survey showed that ... in the United States is caused ... of these species belong to three major ... defoliators, including the velvet bean caterpillar ... (Hubner), the soybean looper ... and the green cloverworm, Plathypena scabra (F.) ... including the Mexican bean beetle ... beetle, Cerotoma trifurcata (Forster) ... the southern green stink bug ... Nilaparvata ... (Dallas) ...

SECTION 2 - SOYBEANS

1. Commodity information.--Soybeans were grown on 70.5 million acres in the U.S. in 1979, producing 2,267.6 million bushels of grain currently valued at ca. $13.8 billion (61). The national average yield in 1979 was 32.2 bushels/acre. Soybean production is concentrated from the Atlantic and Gulf coast westward and northward between latitudes 28° and 46° north. Few soybeans are planted west of the 98° meridian (5). Two states, Iowa and Illinois, annually produce one-third of the soybean grain. The most typical agroecosystems are soybean-corn-forage in the Midwest and soybean-corn-cotton-small grain, soybean-grassland, soybean-rice, and soybean-sugar cane in the South. Soybean grain is an important domestic and export commodity.

2. Arthropod pests of soybeans.--A survey was conducted of entomologists in 18 states which account for 80% of the total acreage planted to soybeans in the United States. Despite the relative richness of the insect fauna found in soybeans, the survey showed that 83.2% of the insect damage to soybeans in the United States is caused by no more than eight species. Seven of these species belong to three major guilds or complexes: (a) lepidopterous defoliators, including the velvet bean caterpillar, *Anticarsia gemmatalis* (Hubner), the soybean looper, *Pseudoplusia includens* (Walker), and the green cloverworm, *Plathypena scabra* (F.); (b) coleopterous defoliators, including the Mexican bean beetle, *Epilachna varivestis* Mulsant and the bean leaf beetle, *Cerotoma trifurcata* (Forster); and (c) pod feeding Pentatomidae, including the southern green stink bug, *Nezara viridula* (L.), and the green stink bug, *Acrosternum hilare* (Say). The eighth species, the corn earworm, *Heliothis zea* (Boddie), also called the bollworm, is locally

SECTION 7 - SOYBEANS

[illegible] Importance.--Soybeans were grown on 70.5 million acres [in t]he U.S. in 1979, producing 2,267.6 million bushels of grain worth ca. $13.8 billion (61). The national average yield in 1979 was [illegible] bushels/acre. Soybean production is concentrated from the Atlantic [and G]ulf coast westward and northward between latitudes [illegible] and [illegible] north. [Soy]beans are planted west of the [illegible] meridian (?). Two states, [illegible] I[illegible], annually produce one-third of the soybean [illegible]. The most [illegible] agroecosystems are soybean-corn-[illegible] [illegible] [illegible] cotton-small grain, soybean-grass land, soybean-rice, and [illegible] in the South. Soybean [illegible] is an important [illegible] [illegible] [illegible]ity.

Arthropod [illegible] of soybeans.--A [illegible] [illegible] [illegible] of [illegible] [illegible] in 18 states which account for 80% of the total acreage planted in [illegible] in the United States. Despite the [illegible] [illegible] [illegible] the [illegible] [illegible] to soybeans, the survey showed that [illegible] of the insect damage [illegible] in the United States is caused by no more than eight species. [illegible] of these species belong to three major guilds or complexes: (a) [illegible] defoliators, including the velvet bean caterpillar, [illegible] [illegible] (Hubner), the soybean looper, Pseudoplusia includens [illegible] and the green cloverworm, Plathypena scabra (F.); (b) [illegible] [illegible], including the Mexican bean beetle, Epilachna varivestis Mulsant, [illegible] [illegible] leaf beetle, Cerotoma trifurcata (Forster); and (c) [illegible], [illegible] the southern green stink bug, Nezara viridula (L.), [illegible] [illegible] hilare (Say). The eighth species, the [illegible], also called the [illegible], is locally

important in southern states as a foliage and pod feeder. Six other species account for 14.8% of the damage by insects to soybeans. These species are the tobacco budworm, Heliothis virescens (F.), the beet armyworm, Spodoptera exigua (Hubner), the threecornered alfalfa hopper, Spissistilus festinus (Say), the black cutworm, Agrotis ipsilon (Hufnagel), the lesser cornstalk borer, Elasmopalpus lignosellus (Zeller, and grasshoppers mainly in the genus Melanoplus. Another 11 species or species complexes may cause sporadic damage, two percent, in the very limited areas (77). There are no records of exotic insect pests of soybeans being introduced into the United States (77).

The biology of the eight major pests species have been studied extensively since the increase in soybean production in the United States and the world in the past 30 years (18,19,22,24,34,35,49,55,68,70,79,78,107, 114,116,117,129,158,161,164,165,177,178,188). A summary of the general biological information and areas of impact of these eight species are presented in Table 2.

3. Use of EPN in producing soybeans.--EPN is used as a foliage spray to control the insect pests of soybeans. It is effective against both insects and mites. EPN is used in combination with methyl parathion and this mixture is favored since it controls the resistant corn earworm and there is no mite build-up in treated fields following use of this insecticide mixture (89). The mixture of EPN plus methyl parathion is the most widely-used insect spray on soybeans in the south-central states and it is the popular choice of many soybean growers in that area. The usual recommended dosage is 0.25 pound ai EPN/A in combination with 0.25 pound ai methyl parathion/A for foliage feeding insects and stink bugs and 0.5 pound ai EPN + 0.5 pound ai methyl parathion/A for the corn earworm (9,28,46,47,45).

[illegible] in northern states as a foliage and pod feeder. [illegible] other spec[illegible] for 14.8% of the damage by insects in soybeans. [illegible] tobacco budworm, *Heliothis virescens* (F.), the [illegible] (Hubner), the [illegible] *Spodoptera* [illegible] (Say), the [illegible] *Agrotis ipsilon* (Hufnagel), the [illegible] stalk borer, *Elasmopalpus lignosellus* (Zeller), [illegible] genus *Heliothis*. [illegible] 11 species [illegible] to damage [illegible] two percent. Of the very limited [illegible] ble of exotic insect pests, [illegible] et (77).

[illegible] biology of the eight major pests [illegible] the increase in soybean [illegible] ports in the past 30 years (13, [illegible] 116,117,129,158,161,164,165,177,178,188). [illegible] cal information and status of impact [illegible] species are [illegible] Table 2.

[illegible] se of EPN in producing soybeans.—EPN [illegible] the insect pests of soybeans. It is [illegible] mites. EPN is used in combination with methyl parathion and this [illegible] avored since it controls the [illegible] in treated fields following use of this insecticide. The mixture of EPN plus methyl parathion [illegible] yields [illegible] soybeans in the south-central States and [illegible] them growers in that area. The usual recommended [illegible] acre in combination with 0.25 pound of methyl [illegible] and stink bugs and 0.5 pound EPN [illegible] for the corn earworm (9,28,63,[illegible]).

Table 2. General biological features of and nature of damage caused by eight insect species responsible for about 83% of the damage caused by insects to soybeans in the United States.

Guild and species	Common Name	Biological Features	Nature of Damge	Impact[1/]
Lepidopterous Defoliators				
Anticarsia gemmatalis	Velvetbean caterpillar	Overwinter southern Florida, Caribbean Islands; migrate north in spring. 3-4 generations in south; 2 generations north. Mostly legume hosts, but feed also on plants of 3 other families.	Larvae feeding on foliage.	AL, AR, FL, GA, LA, MO, MS, NC, OK, SC, TX, VA
Pseudoplusia includens	Soybean looper	Overwinter as pupae. 3-4 generations/yr. Rather polyphagous including hosts in various plant families, but preferring legumes.	Larvae feeding on foliage.	AL, AR, FL, GA, LA, MO, MS, NC, OK, SC, TX, VA
Plathypena scabra	Green cloverworm	Overwinter as adults in southern latitudes, migrate north. 2-4 generations/yr. Mostly legume hosts.	Larvae feeding on foliage	AR, IA, IL, IN, KY, LA, MD, MO, MS, NC, OK, TX, VA
Coleopterous Defoliators				
Epilachna varivestis	Mexican bean beetle	Overwinter as adults. 2-4 generations/yr. Oligophagous restricted to Faboideae.	Adults and larvae feeding on foliage	AL, IN, KY, MD, NC, SC, TN, VA
Cerotoma trifurcata	Bean leaf beetle	Overwinter as adults. 2-3 generations/yr. Oligophagous - restricted to legume hosts.	Adults: leaf-feeders; occasionally pod feeders; may transmit bean pod mottle and other viruses. Larvae: root and nodule feeders.	AL, IL, IN, KY, LA, MS, NC, OK, VA, AR

Table 2. General biological features of and nature of damage caused by eight insect species responsible for about (Cont'd.) 83% of the damage caused by insects to soybeans in the United States.

Guild and species	Common Name	Biological Features	Nature of Damage	Impact[1/]
Pod Feeding Pentatomidae				
Nezara viridula	Southern green stink-bug	Overwinter as adults. One generation on soybeans. Polyphagous.	2-5th instar nymphs and adults mostly on pods and seeds. May transmit yeast spots disease.	AL, AR, FL, GA, LA, MS, SC, TX
Acrosternum hilare	Green stink-bug	Same as *N. viridula*	Same as *N. viridula*	FL, GA, KY, LA, MS, NC. OK, SC, TX, VA
Pod Feeding Lepidoptera				
Heliothis zea	Corn earworm	Overwinter as pupae in soil. 1-2 generations on soybeans. Polyphagous.	Larvae mostly pod feeders but may feed on foliage and growing tips in early infestation.	AL, AR, FL, GA, LA, MD, MO, MS,

1/ States reporting economic infestation of each pest (based on 18 major soybean producing states) though economic density may not occur annually.

This mixture is usually applied by aircraft and fields are sprayed one to two times per season, depending on pest density. There are adequate margins of safety for all EPN applicator personnel wearing protective clothing and respirators (47). Flaggers, by the nature of their job function, are most likely to be at risk from EPN application. Pest scouts and workers are required to wait 24 hours after application before entering EPN treated fields and 48 hours if mixture of EPN + methyl parathion is used. Data on formulation, methods of application, application rate, and application equipment are presented in Table 3.

While several south central states recommend EPN + methyl parathion for soybean insects, most use occurs in Arkansas where ca. 250,000 acres and in Mississippi where ca. 500,000 acres of soybeans are treated annually with EPN (89,110,8). Alabama and Louisiana collectively treat less than 20,000 acres with EPN each year (138,149). Thus, approximately one percent of the U.S. soybean acreage is treated annually with EPN. In years of pest outbreak such as in Arkansas in 1969, 75% of soybean acreage (3.3 million acres) was treated in that state alone.

EPN is not used on soybeans in the north central soybean-growing states since pest problems are much less frequent and alternative insecticides are often already available on the farm or can be readily purchased from a local dealer or custom applicator. These alternative chemicals are more available because they are used on other crops such as corn. In the South, EPN is used on cotton and usually in combination with methyl parathion, and the ready availability of this mixture, plus the experience of the applicators in handling and applying the mixture, is an important reason EPN is used on soybeans in southern states (89). Other reasons are:

[illegible]xture is usually applied by a [illegible] and fields are sprayed [illegible] per season, depending on pest density. [illegible] are adequate [illegible] safety for all EPN appl[illegible] personnel [illegible] protective [illegible] ratory (47). [illegible] by the nature of their job [illegible] likely to [illegible] first [illegible] application. Pest scouts and [illegible] quired to wait 24 hours after application before entering [illegible] and 48 hours if mixture of EPN [illegible] methyl parathion is used [illegible] ation [illegible] of application, application rate and application [illegible] are presented in Table 5.

While several south central states [illegible] EPN + methyl parathion [illegible] bean insects, most [illegible] in Arkansas [illegible] Mississippi where ca. 800,000 acres of soybeans are treated [illegible] (85,119,8). Alabama and Louisiana [illegible] acres with EPN each year (132,149). Thus, approximately [illegible] U.S. soybean acreage is treated annually with EPN. In years of [illegible] break such as in Arkansas in [illegible], 75% of soybean acreage [illegible] res) was treated in that state alone.

[illegible] is not used on soybeans in the north centr[illegible] since pest problems are much less. Frequent and [illegible] are often already available [illegible] purchased [illegible] dealer or custom applicator. [illegible] alternative chemical[illegible] ble because they are used on other crops such as [illegible] with, EPN is [illegible] on cotton and especially in combination with methyl [illegible] and the ready availability of this mixture, plus the convenience [illegible] cost [illegible] handling and applying the mixture, is an [illegible]

Table 3. EPN use on Soybeans in the U.S.

<u>Soybean Insects</u>

Aphids
Bean leaf beetle (<u>Cerotoma</u> <u>trifurcuta</u>)
Blister beetles
Corn earworm (<u>Heliothis</u> <u>zea</u>)
Cabbage looper (<u>Trichoplusia</u> <u>ni</u>)
Fall armyworm (<u>Spodoptera</u> <u>frugiperda</u>)
Garden webworm (<u>Achyra</u> <u>rantalis</u>)
Green cloverworm (<u>Plathypena</u> <u>scabra</u>)
Mexican bean beetle (<u>Epilachna</u> <u>varivestis</u>)
Stink bugs
Threecornered alfalfa hopper (<u>Spissistiulus</u> <u>festinus</u>)
Twospotted spider mite (<u>Tetranychus</u> <u>urticae</u>)
Velvetbean caterpillar (<u>Anticarsia</u> <u>gemmatialis</u>)

<u>Label Directions</u>

Apply 0.125 - 0.5 ai/acre EPN when in 4 + 2 methyl parathion and EPN combination and apply 0.2 - 1.0 lb ai/acre EPN when in 3 + 3 methyl parathion and EPN. Aerial application apply in a minimum of 1-3 gals of water. Do not graze or feed forage to animals within 21 days of application.

<u>Parameters for control of insect pests on soybeans</u>:

Formulations	4-3-1 Toxaphene/Methyl parathion/ EPN 4-2 EC methyl parathion/EPN 3-3 EC methyl parathion/EPN
Packaging:	1, 5, 30 and 55 gal drum
Equipment:	Aerial, conventional ground equipment and high clearance, self-propelled equipment
EPN applied by air:	+ 90%

Dosage of EPN:

EPN + Methyl parathion 2-4
EPN + Methyl parathion 3-3

	lb. ai/A EPN
Aphids	.25 - .6
Blister beetle	.25 - .6
Beanleaf beetle	.5
Bollworm	.5 - .75
Cabbage hopper	.25 - .75
Cutworm climbing	.125 - .187
Fall armyworm	.5 - 1.0
Green cloverworm	.25 - .75
Mexican bean beetle	.25 - .375
Stink bug	.187 - .5
Threecornered alfalfa hopper	.125 - .25
Twospotted spider mite	.25 - .375
Velvetbean caterpillar	.25 - .375
Websorm	.125 - .375

EPN + Methyl parathion + Toxaphene 1-3-4

Aphids	0.16 - 0.19 lb. ai/A EPN
Armyworm	"
Bean leaf beetle	"
Corn earworm	"
Grasshopper	"
Green cloverworm	"
Stink bug	"
Velvetbean caterpillar	"

Carrier	H_2O
# of application	methyl parathion + EPN not more than 2/season
Season	when pests appear
Stage of growth	all stages

	Aerial application	Commercial Ground applicator
Vol. finished spray/acre	1-3 gals/acre	6-8 gals/acre
Avg load capacity	800-3000 lb 190 gals*	150-300 gals*
Speed of spraying	100 mph*	4-20 mph*
Boom width	-	40-60 ft*
Droplet size	200-400 microns**	Every droplet size is produced
# hrs/day suitable for spraying	3-5 hrs**	4-6 hrs*
# hrs actual spraying	20% overall	50-60% overall
Avg # acres treated/hr	80-125 acres/hr**	20-60 acres/hr*
Refill time	<10 min.*	<10 min.*

Nurse tank (if used)	1200-1600 gals*
Capacity of transfer system	150-200 gals/min.
Avg # of acres of soybeans/farm	125.5 acres
# lbs of EPN	ca. 400,000***
# acres treated	ca. 750,000***
% of crop treated	ca. 1.0%***
# applicator (aerial)	?
# mixers/loaders	1 per applicator
# flaggers	0 (stationary marker

*Estimated by L. E. Bode, Agricultural Engineer, AGricultural Engineering University of Illinois.

**From estimates by E. D. Thomas, Entomologist, in Dimethoate RPAR Assessment Team report.

***Based on estimated acreage of 70.5 million acres of soybeans in U.S. in 1979 and use of EPN on soybeans at a dosage of 0.25 to 0.5 lb ai/A in Alabama, Arkansas, Mississippi and Louisiana.

(1) EPN controls the major insect and mite pests that attack soybeans (9,28,46,47,45).

(2) EPN is an effective alternative insecticide where pest resistance could become a problem. Knowledgeable world experts on control and toxicology agree that alternating use of various pesticides in an integrated pest management program helps to defer pest resistance (47,106). Avoidance of pest resistance lessens pesticide use.

(3) EPN is an effective substitute insecticide where pests or pest complexes, especially Heliothis spp., have developed resistance to other insecticides (46,47,45). There are no reports of insect pests developing resistance to EPN though the insecticide has been used for 30 years (47).

(4) EPN is economical and cost effective in pest control. Data obtained from two companies (February 1980) reported approximate cost to the grower of one pound active ingredient of EPN is \$4.00; methyl parathion \$2.00; dimethoate, \$5.00; toxaphene \$1.00; methomyl \$11.00; and carbaryl \$2.40. Most EPN applications to soybeans are at a dosage of 0.5 pound ai EPN/A + 0.5 pound ai methyl parathion/A at a cost of \$3.00-\$3.50/A to assure control of the corn earworm. Even at this maximum dosage, the mixture is competitive with the alternative insecticides or mixtures of methyl parathion and carbaryl or toxaphene since carbaryl is recommended at 1.6-2 pounds, toxaphene at three pounds ai/A. Methomyl is recommended at 0.5 pound ai/A for control of the corn earworm. Dimethoate is not effective against the corn earworm. The 0.5 pound EPN + 0.5 pound methyl parathion mixture used on soybeans is economical. The cost of application is the same for all insecticides. Aerial application costs ca. \$3.50/A.

Studies conducted to date have shown that soybeans are very tolerant of defoliation up to the beginning of pod setting. Yield reductions are not expected to occur below 20% defoliation at any time during the growing period (see Table 4 for vegetative and reproductive growth stages) and 30% defoliation can be tolerated up to pod setting and after pod filling without loss of yield. However, without treatment, some fields in the South would be 100% defoliated.

When an insecticide treatment is applied at the 20-30% level of defoliation, there is no way to know whether defoliation without treatment would attain 35, 50 or 100 percent. With the corn earworm, however, consumption of pods with developing grain is a direct loss in yield. As illustrated in Figure 2, loss of pods has a dramatic effect on yield and greater than the effects of loss of foliage (Figure 1). In many circumstances in the south, defoliation and depodding occur simultaneously in the same field. The primary use of EPN + MP on one percent of U.S. soybean acreage is to control the corn earworm and EPN + MP is more economical and effective than any other combination or insecticide applied alone. Treatment scenarios based on cancellation of EPN and use of alternative insecticides would not change the number of acres now treated, but for alternative chemicals, dosage would be higher or costs greater with no increase in control.

Alternative chemicals.--The five insecticides that can be considered alternatives to EPN in controlling insects on soybeans are: carbaryl, dimethoate, methomyl, methyl parathion and toxaphene.

Carbaryl--This insecticide is widely recommended for controlling many insect pests of agricultural crops, including those attacking soybeans. Because it is readily available and because the bollworm does

Table 4. Description of growth stages of soybeans (49a).[a]

Stage no.	Abbreviated stage title	Description
VEGETATIVE STAGES		
VE	Emergence	Cotyledons above the soil surface.
VC	Cotyledon	Unifoliolate leaves unrolled sufficiently so the leaf edges are not touching.
V1	First-node	Fully developed leaves at unifoliolate nodes.
V2	Second-node	Fully developed trifoliolate leaf at node above the unifoliolate nodes.
V3	Third-node	Three nodes on the main stem with full developed leaves beginning with the unifoliolate nodes.
V(n)	nth-node	n number of nodes on the main stem with fully developed leaves beginning with the unifoliolate nodes. n can be any number beginning with 1 for V1, first-node stage.
REPRODUCTIVE STAGES		
R1	Beginning bloom	One open flower at any node on the main stem.
R2	Full bloom	Open flower at one of the two uppermost nodes on the main stem with a fully developed leaf.
R3	Beginning pod	Pod 5 mm long at one of the four uppermost nodes on the main stem with a fully developed leaf.
R4	Full pod	Pod 2 cm long at one of the four uppermost nodes on the main stem with a fully developed leaf.
R5	Beginning seed	Seed 3 mm long in a pod at one of the four uppermost nodes on the main stem with a fully developed leaf.
R6	Full seed	Pod containing a green seed that fills the pod cavity at one of the four uppermost nodes on the main stem with a fully developed leaf.
R7	Beginning maturity	One normal pod on the main stem that has reached its mature pod color.
R8	Full maturity	Ninety-five percent of the pods that have reached their mature pod color. Five to ten days of drying weather are usually required after R8 before the soybeans have less than 15 percent moisture.

[a] A plant at a reproductive stage of growth should be designated with a combination of the V and R stages. For example, a plant at full bloom with 11 fully developed trifoliolates above the unifoliolate nodes would be at stage V12R2, because the unifoliolate nodes should be counted as one.

Figure 1. Effect of defoliation on yield of soybean grain.

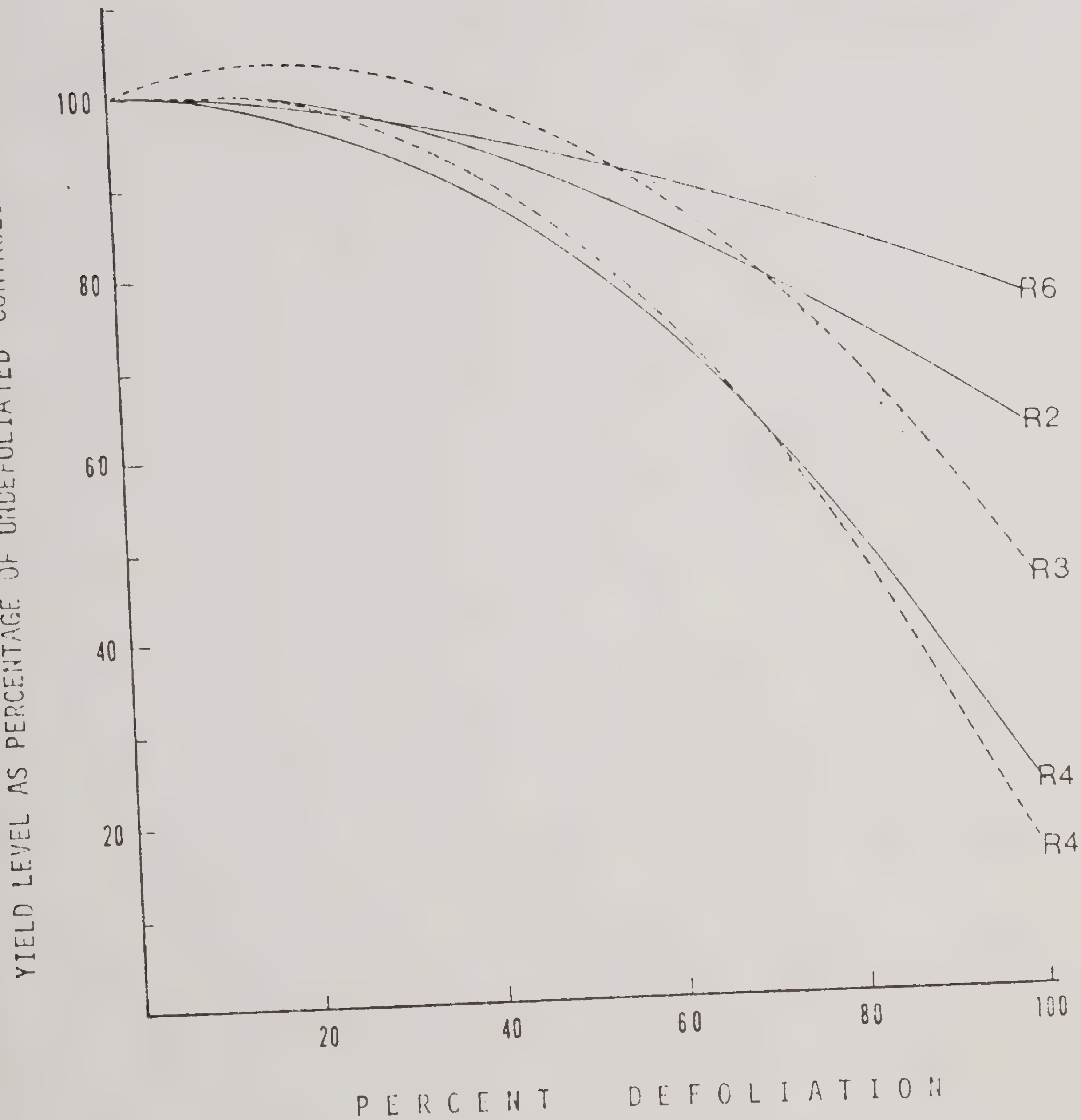
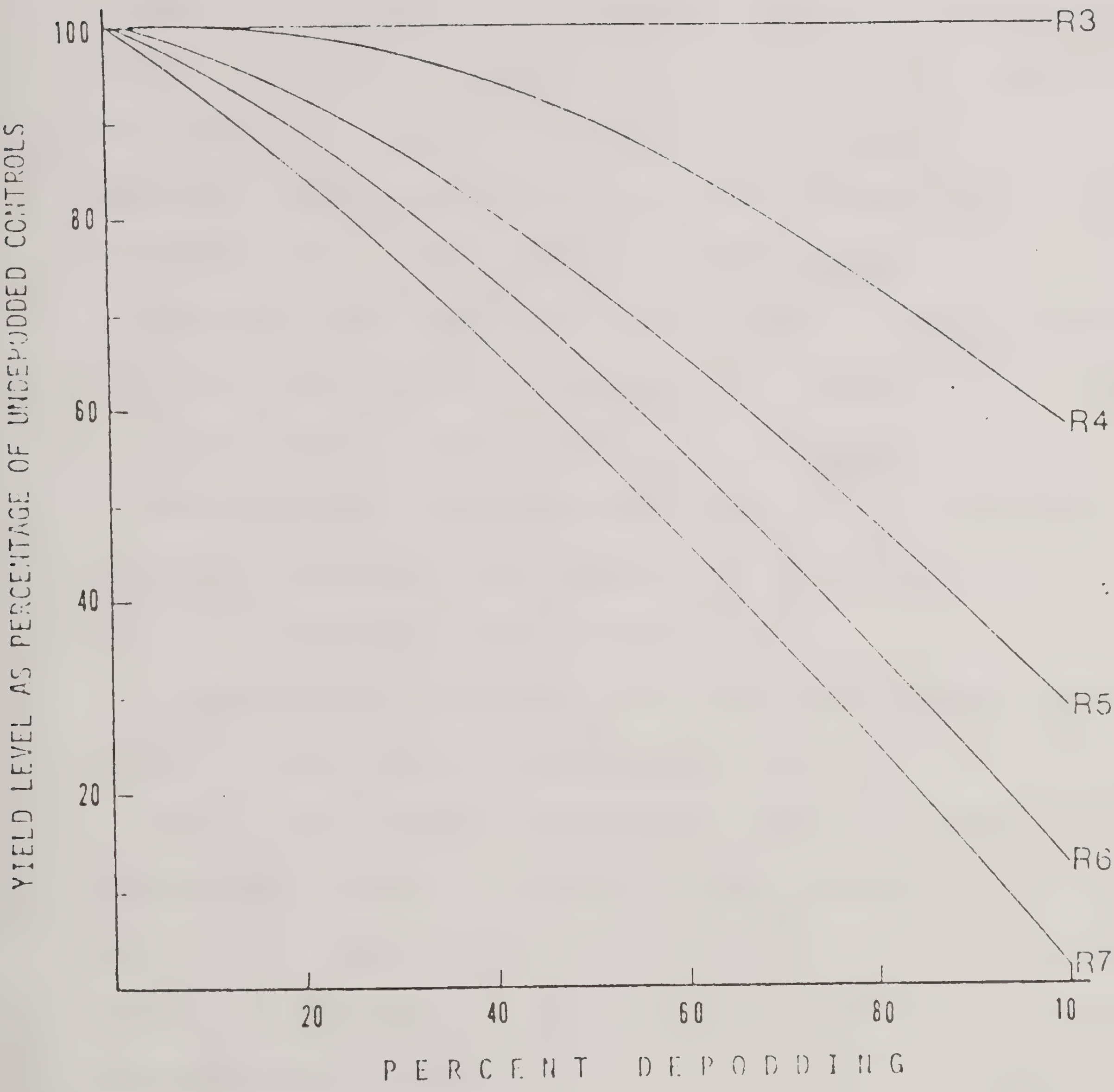


Figure 2. Effect of depodding on yield of soybean grain.



not attack soybeans in northern states, carbaryl is the choice in the major soybean producing areas of the Midwest when pest outbreaks of leaf-feeding caterpillars and beetles occur. Carbaryl is very toxic to predaceous mites that usually keep phytophagous mite populations below the economic threshold in soybeans. In the south where the growing season is longer, mite problems can be aggravated with use of carbaryl. In northern states, mite buildup from use of carbaryl usually occurs so late in the season as to not be a problem. Further, only one application of insecticide is needed in the north, and mites increase most with multiple applications, which is more common in southern states.

Methomyl--This insecticide is a very effective cleanup insecticide against the looper complex when loopers are a problem, but it is used only to a minor extent because of its cost.

Dimethoate--This insecticide is primarily used to control the Mexican bean beetle, grasshoppers and spider mites. Dimethoate is not effective against the pod-feeding bollworm (36).

Toxaphene--This insecticide is not usually recommended or used on soybeans as other insecticides give better control.

Methyl parathion--This insecticide is favored for mixing with EPN. In combination with EPN, it controls the most difficult pests such as the bollworm. Methyl parathion alone is not as effective in controlling soybean pests and especially the resistant bollworm, as when used in combination with EPN (89).

SECTION [illegible]

Major uses - [illegible] is registered for [illegible] of corn, but has limited [illegible] against European corn borer and rootworm beetles.

Commodity Information

a. Geographic distribution - [illegible] acres of corn [illegible] grown [illegible] Illinois, Minnesota, Ne[illegible] Indiana [illegible] Wisconsin, Missouri, Michigan, [illegible] to [illegible] million [illegible] year in the states of [illegible] Pennsylvania, Texas [illegible]

b. Acreage - The acreage [illegible] shown in Table [illegible] of white corn is grown each [illegible] States (170).

Acres of corn grown for [illegible] for 197[illegible], 1978 and 1979 (170).

	1977	1978	1979	
	(1,000 acres)			
[illegible]	70,2[illegible]5	70,[illegible]	[illegible],710	10[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	11[illegible]

[illegible] and Val[illegible] the [illegible] average [illegible]

[illegible],[illegible],000 bushels [illegible] (170).

SECTION 3 - FIELD CORN

A. Major uses - EPN is registered for use against several Arthropod pests of corn, but has limited use against European corn borers and corn rootworm beetles.

1. Commodity Information

a. Geographic distribution - About 80 percent of the 80 million acres of corn is grown in the 12 corn belt states of Iowa, Illinois, Minnesota, Nebraska, Indiana, Ohio, South Dakota, Wisconsin, Missouri, Michigan, Kansas and Kentucky. An additional one to two million acres of corn are grown each year in the states of Georgia, New York, North Carolina, Pennsylvania, Texas and Colorado (170).

b. Acreage - The acreage of corn grown for grain and silage is shown in Table 4a. In addition, approximately 500,000 acres of white corn is grown each year in ten states in the United States (170).

Table 4a. Acres of corn grown for grain and silage in the United States for 1977, 1978 and 1979 (170).

Field Corn Crop	1977	1978	1979	3 yr. Ave. Acres	3 yr. Ave. Yield	3 yr. Ave. Production
		(1,000 acres)			bu.	(000)
Grain	70,972	70,275	70,984	70,710	100.3	7,091,965 bu.
Silage	9,307	8,623	8,002	8,644	13.4 Tons	115,647 Tons

c. Production and Value - The three-year average corn production was 7,091,965,000 bushels. The average price for a

bushel of corn for 1977, 1978 and 1979 was \$2.02, \$2.25 and \$2.44 (190), respectively or an average price of \$2.30 for the three-year period. The three-year average value of the corn grain:

7,091,965,000 bu. x 2.30 = \$16,311,519,500

d. Cultural Practices - Corn is grown as a spring-seeded, full season annual crop. It is planted in rows 30-40 inches apart. Tillage practices prior to planting vary from fall or spring moldboard plowing, which will cover most of the previous crop residue; fall and/or spring chiseling or disking, which will leave some of the previous crop residue on the surface; to no-till, which plants the corn without any previous tilling leaving all of the previous crop residue on the surface.

Fertilizer is applied to nearly all corn acres in a fall or spring application, usually broadcast as granular or liquid and incorporated by disking. Starter fertilizer may be applied as a row application and some post-plant sidedress fertilizer applications are also made. Additional nitrogen may be supplied as anhydrous as pre- or post-planting applications.

Herbicides are applied to nearly all the corn acres as pre-plant soil incorporated, surface applied pre-emergence and post-emergence applications needed; some acres are treated for broad-leaf weed control at various times throughout the growing season.

In areas where corn rootworms are present, corn following corn acres are treated with a planting-time application of a soil insecticide. These are applied in a seven inch band above the seed, lightly incorporated in the top one-half to one inch of soil.

Depending on the effectivenss of the herbicides, corn is usually cultivated at least once, but rarely three times as was so common 30 years ago.

Furrow or sprinkler irrigation is the main source of water in the more western corn belt region and is used to supplement rainfall by some farmers in some years in the portions of the corn belt.

All seed is fungicide treated as purchased and a small amount is treated with a planter-box insecticide treatment to protect against the seed attacking insects.

Harvesting begins in the fall after the crop is mature and the moisture content of the grain is at a level that is desirable for the subsequent use or storage of the grain. Livestock feeders who are equipped to store and feed high moisture grain will begin harvest when the corn is at 28% moisture. Propane gas fueled dryers are used to dry the combined grain down to the 15-16% moisture content that is safe for storage. The increase in cost of this fuel for drying corn will cause many farmers to grow a somewhat shorter season and lower yielding varieties for their area to reduce the amount of drying. Some corn is still harvested in the ear by corn pickers and is stored in corn cribs. Ear corn can be harvested and stored at a higher moisture level than shelled corn. The combine has replaced the corn picker as the predominant method of harvesting corn.

There has been a dramatic decrease in the amount of oat acres and an increase in soybean acres. Continuous corn and a corn-soybean rotation are used extensively. The traditional corn, corn, oats, meadow, meadow rotation is practiced on very few acres.

Depending on the effectiveness of the herbicides, [illegible] usually cultivates at least [illegible] so common 10 years ago.

Furrow or sprinkler irrigation [illegible] of water in the more [illegible] is used to supplement rainfall by some farmers [illegible] belt.

A [illegible] seed is [illegible] is treated with a planter-box [illegible] against the seed attacking insects.

Harvesting begins in the [illegible] the moisture content of the [illegible] for the subsequent [illegible] storage of the grain. [illegible] who are equipped to dry and feed corn with [illegible] harvest when [illegible] corn [illegible] 25% moisture. Propane gas fuel dryers are used to dry [illegible] moisture content [illegible] of this fuel for drying corn will [illegible] somewhat shorter season and lower yielding varieties for this area to reduce the amount of drying. [illegible] corn is still being husked in the ear by corn pickers and is [illegible] Ear corn can be harvested and stored at a higher moisture [illegible] than shelled corn. The combine has [illegible] the predominant method of harvesting corn.

There has been a dramatic decrease in the number of [illegible] acres and [illegible] increase in soybean acres. [illegible] corn and [illegible] used extensively. The [illegible] is practiced on [illegible]

2. Pest Information

Arthropod pests of corn that EPN is registered for use are listed below:

Corn rootworm adults	Fall armyworms
European corn borers	Cutworms (climbing)
Armyworms	Stinkbugs
Spider mites	Cutworms (surface feeding)
Aphids	Twospotted spider mites
Thrips	

Although EPN has not been used extensively to control any of the above pests of corn, the European corn borer and corn rootworms will be examined as these are the major pests of corn and some EPN is used to control these insects.

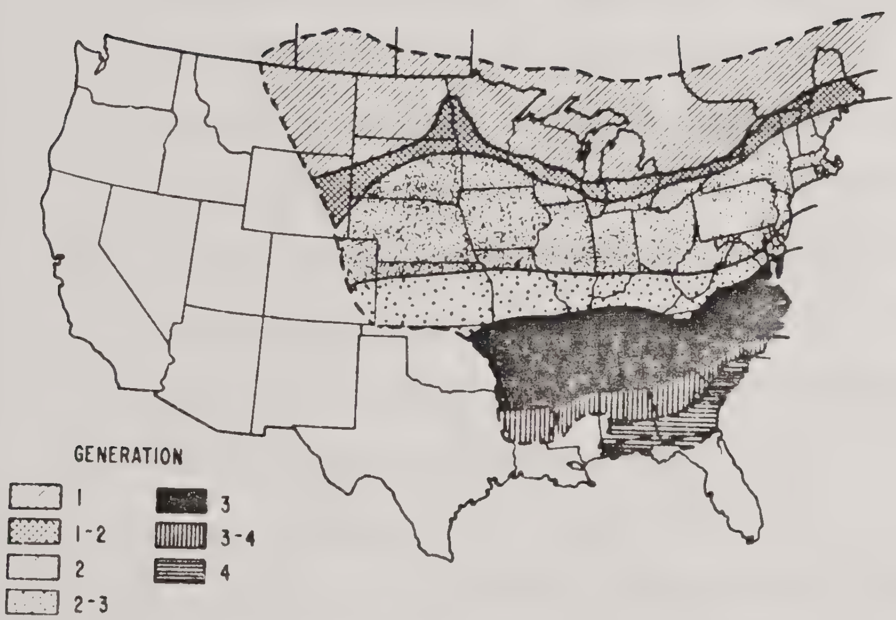
a. Geographic distribution

European corn borer - Ostrinia nubilalis (Hübner)

The European corn borer was introduced into the United States with a shipment of broomcorn from Hungary or Italy to Boston between the years 1909 and 1914 (16). Figure 3 shows the insect has one generation per year in the northern states and as many as four in the southern portions of the country. Two generations commonly occur in the heart of the corn belt states of Nebraska, Iowa, Illinois, Indiana and Ohio.

The borer goes through four stages of development--egg, larva (borer), pupa and moth. The borers pass the winter as full grown larvae in cornstalks, corn cobs or weed stems. The overwintered borers pupate in May. When the moths emerge in the spring, they spend the daytime in small grain fields

Figure 3. Generations of European Corn Borers in the United States (146).



or in grassy fence rows and grass waterways. On warm, calm evenings, they fly into corn fields and lay their eggs in the tallest or most advanced corn. The eggs are deposited in masses of 15 to 30 eggs/mass on the underside of corn leaves near the midrib. The eggs hatch in four to seven days. The small larvae move down the leaf to the whorl to feed (119).

Corn borers damage the plant by leaf feeding which results in loss of leaf tissue, interference in the movement of plant nutrients and midrib breakage. Larger larvae bore into the stalk destroying food-conducting channels of the plant. This weakens the plant, resulting in stalk breakage, smaller ear size and weight and reduced yield. Tunneling also makes the plant vulnerable to organisms that cause stalk rots (119).

Subsequent generations feed on leaf sheaths and collars and also tunnel in ear shanks and feed on the silks, kernals, and cobs resulting in yield loss, quality impairment and dropped ears (119). Insecticide controls are applied at egg hatch and young larval stages.

b. Losses in absence of insecticides

Corn borer populations may fluctuate up or down each year due to the many influential biotic and climatic factors that affect the insect.

Some factors that influence European corn borer populations are (152):

Weather - The most vulnerable stage of the European corn boreris the moth. Unseasonably cool evening temperatures during the egg laying period will reduce expected corn borer numbers. Heavy rain/wind storms that occur during the egg laying period will also exert a negative influence on

or in grassy fence rows and grass [illegible]. On warm, calm evenings, they fly [illegible] and lay their eggs in the earliest or most advanced corn. The eggs are deposited in masses of 15 to 20 eggs each on the underside of corn leaves [illegible] the [illegible]. The eggs hatch in four to seven days. The small larvae move down the leaf to the whorl [illegible] (111).

Corn borers damage the plant by [illegible] feeding which [illegible] in loss of leaf tissue [illegible] of plant nutrients and [illegible] [illegible] the stalk [illegible] [illegible] the plant. This weakens the plant, resulting in [illegible], ear size and weight and reduced yield. [illegible] the plant vulnerable to [illegible].

Subsequent generation [illegible] and also tunnel in ear [illegible] the silks, kernels, and cobs resulting in [illegible] impairment of [illegible] (119). Insect [illegible] eggs hatch and young larvae [illegible]

b. Losses in absence of insecticide.

Corn borer populations may [illegible] year due to the many [illegible] that affect the insect.

Some factors that influence European corn borer populations are (121):

Weather [illegible] vulnerable stage of the European corn borer [illegible] [illegible] with [illegible]

the population. For example, in 1979, corn borer populations were expected to be above average with many fields requiring an insecticide treatment. Numerous storms that resulted in heavy rains that were accompanied by high winds reduced the corn borer potential and virtually no insecticide applications were applied.

Stalk Destruction and Tillage Practices - Harvest operations destroy many corn borer larvae. Fall or spring stalk-chopping, disking and plowing destroy many more. Many larvae survive in the stems of weeds along field margins and in corn stalks of fields planted to oats, since many stalks are left on the soil surface when prepared for drilling or seeding oats (62,63).

Two factors override the recommendation of using stalk destruction as a method of controlling corn borers - 1) excess energy use and 2) soil conservation. Wind and water erosion is of major concern and crop residues left on the soil surface reduce the amount of erosion. In Iowa, some form of reduced tillage (chisel, disk, field cultivator, no-till planter) has replaced the moldboard plow on about 50% of the acres planted to corn and soybeans each year (4). The Soil Conservation Service emphasizes that plowing and burying crop residues increases soil erosion. In addition, all of the tillage implements that leave more residue on the surface also require less fuel per acre of tillage than the moldboard plow.

the population. For example, in 1978, corn borer popula- tions were expected to be above average with [illegible] requiring an insecticide treatment. Numerous rains [illegible] resulted in heavy rains that were accompanied by high win[illegible] reduced the corn borer potential and [illegible] insecti- cide applications were [illegible].

Stalk destruction and [illegible]. Harvest operations destroy many corn borer larvae. [illegible] stalk-chopping, disking and plowing destroy [illegible] larvae [illegible] in the stems of weeds along field margins and [illegible] corn stalks in fields [illegible] stalks are left on the soil surface [illegible] drill [illegible] used as [illegible] (72,67).

Two factors [illegible] the recommendation of stalk destruction as a method of controlling corn borers: 1) energy use and 2) soil conservation. When [illegible] amount is of major concern, and crop residue left on the soil to reduce the amount of erosion. [illegible] tillage (chisel, disks, field cultivator, [illegible]-till planter) has replaced the moldboard plow on about 50% of the acres planted to corn and soybeans each year (4). The soil [illegible] [illegible] Service suggests that plowing and [illegible] [illegible] increases soil erosion. In addition, [illegible] tillage [illegible] that leave more residue [illegible] [illegible] as [illegible] tillage than the [illegible]

Date of Planting - A five year review of research conducted in three states (152) revealed that early-planted corn outproduced the late-planted by an average of 6.8 bushels per acre. The difference ranged from 5.4 bushels in Iowa to 6.3 bushels in Minnesota and 8.6 bushels in Ohio. Because a one bushel drop in expected yield will occur for each day planting is delayed after May 10 in Iowa (160), agronomists recommend planting as soon as soil temperatures warm to 50^{o}F and to complete planting by mid-May if possible. Maximum yields and profit will be made from planting as early as possible and treat for European corn borers in those years when the population reaches economic infestations.

Plant Stand and Fertilizer - Second-generation corn borer populations are greater on corn grown in fertile soil when compared to corn grown in fields where commercial fertilizers were not used (62). Adequately fertilized plants will tend to be more succulent and attractive for egg laying than nonfertilized plants. There has been a gradual trend toward increasing the plant stand along with increasing the level of fertility. With increased planting rates and increased usage of fertilizer, it is possible that planting methods could enable more borers to survive simply by providing more surface area upon which the young larvae could crawl and to become established (62).

Biological Organisms - Corn borers can become infected with a protozoan *Nosema pyrausta*. Infected larvae are less likely to survive the winter and infected adults lay fewer

eggs (62,86). A fungus, Beauvaria bassiana, can also cause mortality to a segment of the corn borer larvae. The climatic conditions that favor both of these beneficial organisms are not fully understood (86). Lady beetles and the tiny flower bug, Orius, will feed on a small number of corn borer eggs and tiny larvae each year. Corn borers in corn fields located near wooded areas often are preyed upon during the winter months by woodpeckers. A small number of larvae are also consumed during the winter by pheasants.

The role that these biological organisms contribute to the overall corn borer population is negative, but usually insignificant (86).

Resistant Hybrids - Research corn breeders and entomologists have been able to develop inbred corn lines which contain a physiological chemical, Dimboa, which is responsible for resistance to the first generation of the European corn borer. Upon maturation of the corn plants, however, the level of Dimboa decreases so that these resistant lines are no longer resistant to subsequent generations. Most seed corn-producing companies have available commercial hybrids with high to intermediate resistance to leaf feeding by first-generation corn borers.

Unfortunately, the genetic yield potential is not as great for these Dimboa-containing inbreds as others. So, the popular hybrids with growers are those that have a high yield potential but are not very resistant to European corn borers. Although all of the hybrids grown today are not as susceptible to corn borer attack as those hybrids grown in the 1940's and early 1950's, the most popular ones are not as

eggs (62,24?). A fungus, *Beauveria bassiana*, can also cause mortality to a segment of the corn borer larvae. The climatic conditions that favor both of these beneficial organisms are not fully understood (85). Lady beetles and the minute flower bug, *Orius*, will feed on a small number of corn borer eggs and young larvae each year. Corn borers in corn fields located near wooded areas often are preyed upon during the winter months by woodpeckers. A small number of larvae are also consumed during the winter by [illegible].

The role that these biological organisms contribute to the overall corn borer population is negative, but is [illegible] incidental (85).

Resistant Hybrids - Research corn breeders and entomologists have been able to develop [illegible] containing a physiological chemical, Dimboa, which is responsible for resistance to the first generation of the [illegible] corn borer. Upon maturation of the corn plants, however, the level of Dimboa decreases so that these resistant lines are not resistant to subsequent generations. [illegible] commercial companies have available commercial hybrids with intermediate resistance to leaf feeding by first-generation corn borers.

Unfortunately, the genetic yield [illegible] is not great for these Dimboa-containing hybrids [illegible] the popular hybrids with greater [illegible] have [illegible] yield potential but are not very resistant to the corn borer. Although all of the hybrids grown today are not as susceptible to corn borer [illegible] as those hybrids grown [illegible]

[illegible] 60 to 70%.

resistant as others which the seed industry has available.

A total of 1,167 inbred lines of corn were rated for resistance to leaf feeding by larvae of the first generation European corn borers by Guthrie and Dicke (56), so sources of lines that are resistant are known to the seed industry.

Summarizing the results of a five year study conducted at Ohio, Minnesota and Iowa, Sparks et.al. (152) states that the susceptible hybrid outproduced the resistant hybrid by an average of 11.6 bushels per acre in the early planting and by 9.3 bushels per acre in the late planting for an average of 10.4 bushels per acre.

When first generation corn borer populations are low to moderate, susceptible hybrids will outyield resistant hybrids. Only when corn borer populations are high would growers benefit from planting the lower yielding resistant varieties (152).

Yield losses have generally been established at 3%/borer/plant (125), but vary with the time of infestation, stage of plant development and geographical location (48,82). A more recent and comprehensive study of losses due to corn borers was reported by Lynch (93). He studied the losses in yield due to corn borers infested at different stages of plant development and different levels of infestation for four corn hybrids commonly grown in the midwest. Two of the hybrids contain A619 x A632 and B37 x Oh43. A619 and Oh43 are inbreds that are resistant to leaf feeding and when combined as above, the hybrid would be considered to be intermediate in resistance. The other two hybrids, B73 x Mo17

and Mo17 x N28 would be considered susceptible because of Mo17's extreme susceptibility to corn borers. Lynch (93) determined that the yield losses resulted primarily from physiological damage (less grain produced) due to corn borer infestation rather than losses due to unharvestable (dropped) ears. When infestations were made during the whorl stages of plant development, yield losses per unit of infestation were greater for the susceptible, long-season hybrid than for the mid-season hybrid with an intermediate level of resistance. However, the yield potential of the long-season hybrid, especially B73 x Mo17, was great enough to compensate for the greater loss.

Infestations occurring at pretassel and pollen-shedding (in Iowa, second generation) stages, losses tended to be greater for the long-season than for the mid-season hybrids. Because of the tendency to plant such a high percentage of the corn acres to full-season but corn borer susceptible varieties, Lynch (92) believes the 3%/borer/plant estimate used to assess corn borer losses actually underestimates the true losses.

The most recent national estimates of damage by the European corn borer printed in the Cooperative Plant Pest Report is for 1976. Listed in Table 5 are the estimates of production and loss for selected corn producing states for 1976. The index of three percent loss per borer per plant was used to compute the loss in bushels.

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Infestations occurring at [illegible] pollen-shedding (4th instar, second generation) stages, losses were [illegible] greater for the long-season than for [illegible] season hybrids. Because of the tendency to plant such high percentages of the corn acres to full-season but corn borer susceptible varieties, Lynch (32) believes that the 3%/borer/plant estimate used to assess corn borer losses actually underestimates the true losses.

The most recent national estimates of damage by the European corn borer printed in the Cooperative Plant Pest Report is for 1976. Listed in Table 9 are the estimates of production and loss for selected corn producing states [illegible]. The index of [illegible] percent loss per borer per plant was used to compute the loss in bushels.

Table 5. Estimates of Damage by the European Corn Borer to Corn Grown for Grain in the U.S. in 1976 (173).

	Total State Production	Estimated Data			
		Value Per Bushel	Value of Production	Loss of Crop	
	1,000 bu.	Dollars	$1,000	1,000 bu.	$1,000
Delaware	18,275	2.45	44,774	454	1,113
Illinois	1,250,830	2.40	3,001,992	12,184	29,241
Indiana	693,000	2.30	1,593,900	7,239	16,650
Iowa	1,147,500	2.35	2,696,625	43,672	102,628
Kansas	170,050	2.30	391,115	1,109	2,550
Maryland	57,330	2.45	140,459	1,158	2,836
Michigan	141,450	2.25	318,263	2,370	5,332
Minnesota	330,400	2.40	792,960	10,110	24,263
Missouri	173,850	2.40	417,240	5,940	14,256
Nebraska	514,600	2.30	1,183,580	29,110	66,953
North Dakota	7,200	2.40	17,280	54	131
Ohio	359,920	2.30	910,616	2,645	6,084
South Dakota	37,200	2.40	89,280	713	1,711
Wisconsin	148,240	2.45	363,188	1,112	2,724
TOTALS	5,085,845		11,961,272	117,870	276,472

A list of estimated losses caused by the European corn borer during the last six years (latest available) are listed in Table 6 to indicate the variability in losses in each successive year.

The loss was 2.32 percent of production in these 14 states or about 1.90 percent of the total 1976 crop. These losses would not have included any cost of controls and would be in addition to controls.

Table 6. Estimates of Damage by the European Corn Borer to Grain Corn in 14 states where the fall survey was conducted.

Year	Bushels	Dollars
1976	117,870,000	276,472,000
1975	223,221,000	549,685,000
1974	42,599,000	148,865,000
1973	139,395,000	329,272,000
1972	65,821,000	83,367,000
1971	305,545,000	319,777,000

Figures 4 and 5 (168,169) show the geographic distribution of the northern and western corn rootworm in the United States. These important pests of corn overwinter in the egg stage and the eggs are laid in the soil in corn fields in late July and August. Whenever corn follows corn, there is potential for rootworm damage. The eggs hatch in early June and the larvae feed on corn roots causing damage. Severe root pruning can cause the plant to lodge (fall over) as well as reduce yields because of smaller ears. The larvae complete their development in July, pupate, and the adult beetles emerge in late July and August.

Rootworms are easily controlled culturally by crop rotation. Since most of the eggs are laid in corn fields, damage can be avoided by not planting corn after corn. Because rootworm damage on corn after corn fields in the midwest is highly predictable, many farmers have adopted a corn-soybean rotation. This procedure avoids rootworm damage and the need for a soil insecticide for rootworm control.

Figure 4. Distribution of Western Corn Rootworm

Diabrotica virgifera

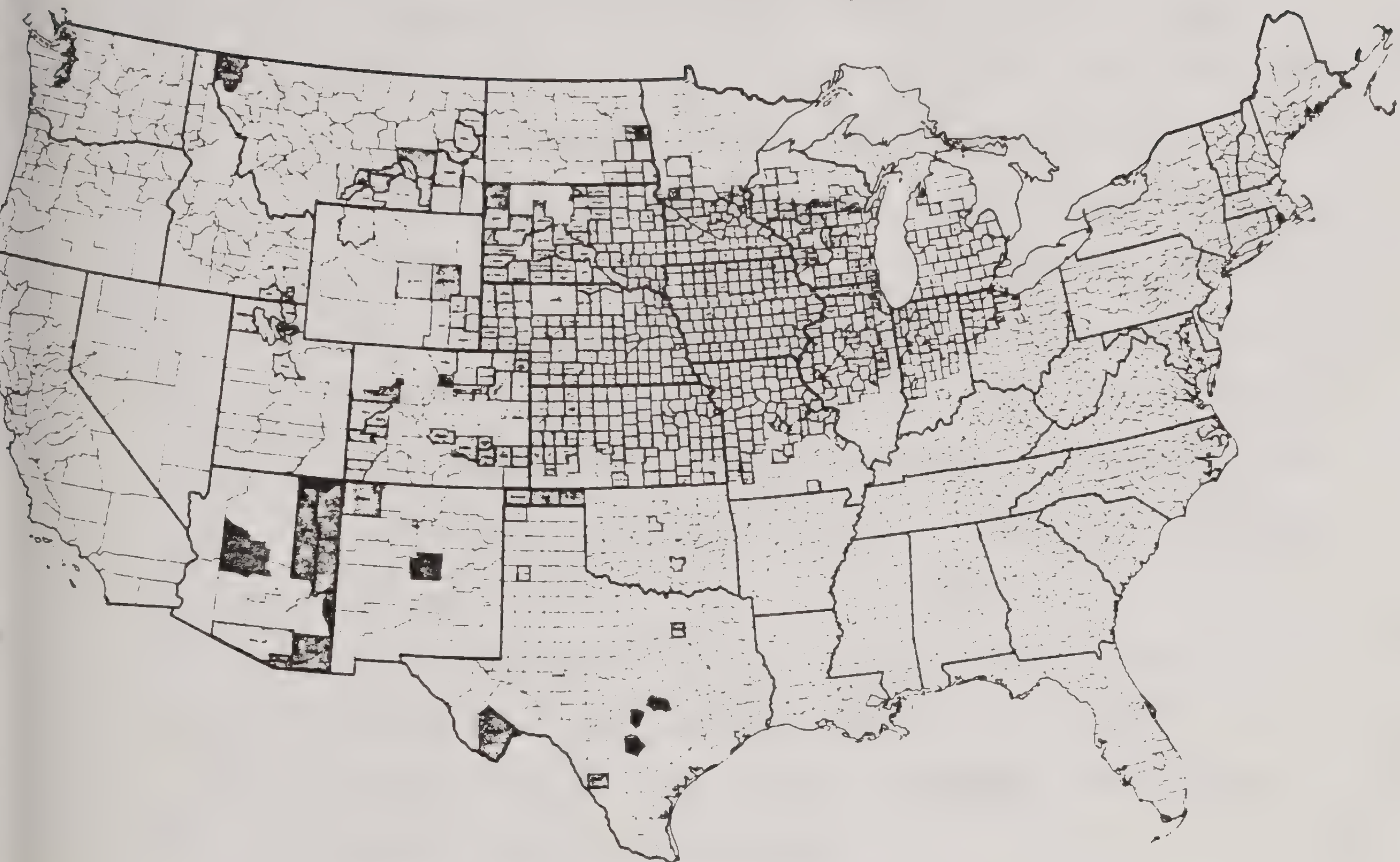
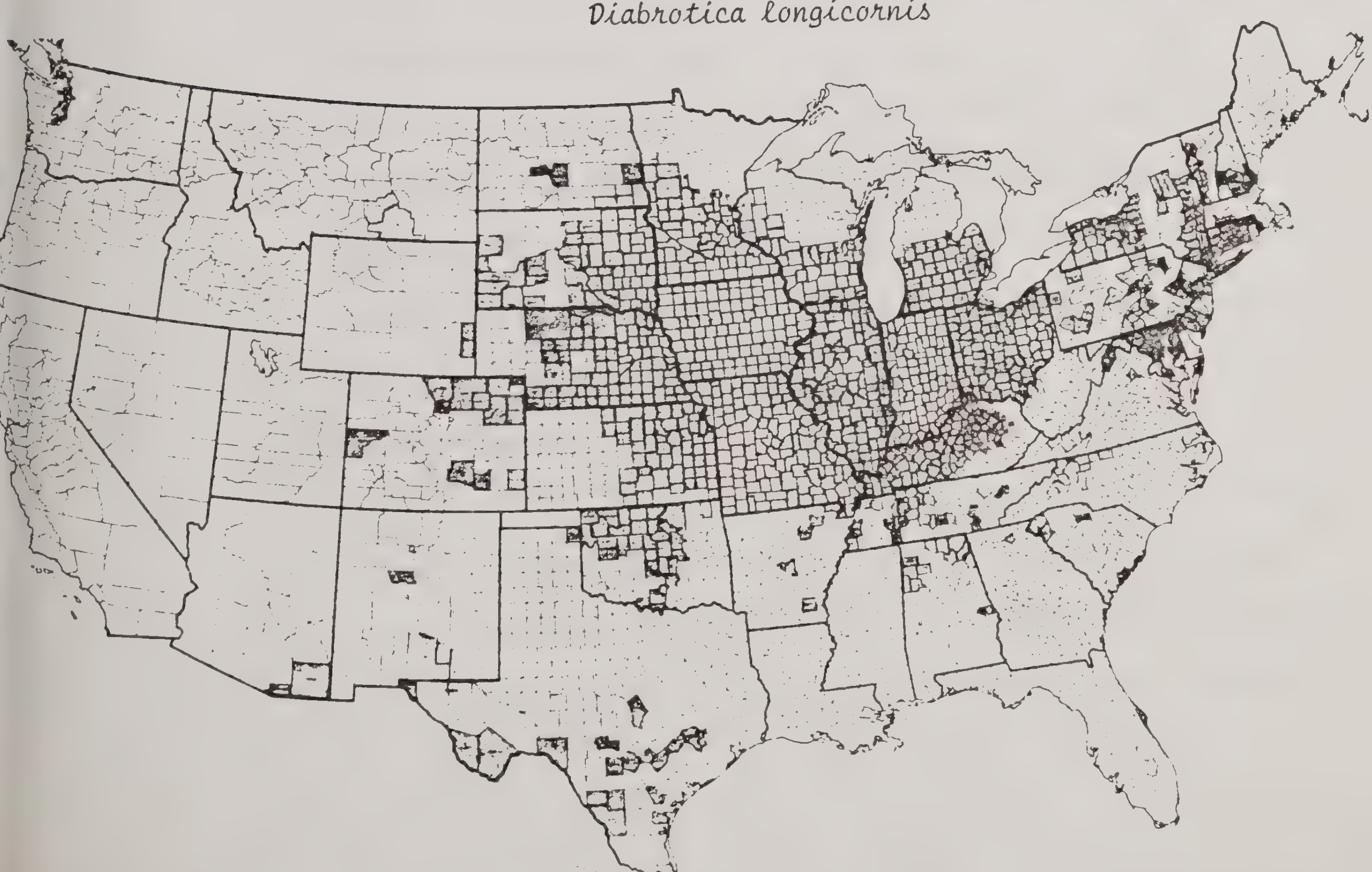


Figure 5. Distribution of Northern Corn Rootworm

Diabrotica longicornis



Nearly half of Iowa's corn acres each year are planted on fields where corn was grown the previous year (69). The reasons for each farmers selection of crops to grow on his/her farm each year are many. Government programs, anticipated price, harvest equipment, storage facilities, livestock enterprise and need for grain or hay as feed, previous herbicide use (some carryover and cause injury to soybeans), topography of farm, a particular weed problem and spread of work load at planting and harvest are some of the reasons that each farmer uses in planning his cropping plans each year.

In Iowa in 1977, 91% of the corn following corn acres (5.7 million acres) were treated at planting-time with a soil insecticide for rootworm larval control (69). EPN is not registered or used to control rootworm larvae.

Rootworm beetles feed on corn leaves, silk and pollen. Usually, peak beetle numbers occur after the corn crop has pollinated. A few late pollinating fields may occur each year that will have five to 15 beetles present per ear tip. Their extensive silk feeding can keep the silks clipped and prevent normal pollination which results in reduced yields. When this situation occurs, an insecticide application is needed to stop this silk clipping.

3. Use of Pesticides in Producing Corn

a. European Corn Borers

As Tables 5 and 6 indicate, the need for insecticides to control corn borers will vary each year and will vary from one geographic area to another. This is because of the important role that the weather and other factors have in influ-

Nearly half of Iowa's [illegible] acres corn each year are planted on fields where corn was grown the previous year (25). The reasons for each [illegible] of crops [illegible] farm [illegible] year [illegible]. Convenient [illegible], [illegible] equipment, storage facilities, livestock [illegible] grain or hay to feed, [illegible] [illegible] (some [illegible] cause [illegible] in [illegible]). [illegible] and [illegible] of [illegible] of [illegible] [illegible] planted each [illegible]

In Iowa in 1977, [illegible] million acres were [illegible] [illegible]-ide [illegible] used to control [illegible]

Rootworm [illegible] peak beetle [illegible] after the corn [illegible] few late pollination fields [illegible] the [illegible] beetles [illegible] feeding can [illegible] silks [illegible] which result in reduced yields. [illegible] an insecticide application [illegible] to stop this [illegible]

Use of Pesticides in Producing Corn

a. European Corn [illegible]

As Tables 5 and 6 indicate, the need [illegible] insecticides [illegible] corn borers will vary each year and will vary from [illegible] area to [illegible]. This is because of the [illegible] [illegible] and other factors [illegible]

encing the magnitude of the corn borer populations. Traditionally, insecticides are not applied for European corn borer control unless the infestation is high enough to justify treatment. In other words, very few prophylatic or preventative treatments are applied.

Recommendations to treat field corn for the first-generation corn borer vary from treating when 35% to 75% of the plants are infested. Infestations are determined by observing leaf feeding. The lower economic threshold is used on fields with higher yield potential (135+ bushels/acre).

Treatment times are likely to occur in mid-May in Southern Missouri, mid-June in central Iowa and late June in central Wisconsin (119).

Materials

Granular insecticides consistently give better control than sprays (102). This is because the granules are "caught" by the whorl leaves and "funneled" down into the whorl where they come in contact with the small corn borers. Granule formulations have some advantages over sprays. These are:

1. No mixing is needed.
2. No water is needed.
3. Treatment can be applied at higher wind velocity.
4. The personal hazard is reduced.
5. There is less hazard to honeybees and other beneficial insects.

Because there is little or no granular application equipment available on farms, applications are applied by aircraft. This may increase the cost of application, but it insures the application by trained and certified personnel.

Listed in Table 7 are the insecticides suggested for controlling European corn borers by the USDA (166).

Table 7. Insecticides Registered for European Corn Borers

Crop & Pest	Insecticide	Min. Days from Last Application to Harvest or Feeding	Pounds of Active Ingredient to Apply per acre
Corn European corn borer	Diazinon	-	1-2.0
	Fonofos (Dyfonate 20G)	30	1.0
	EPN	14	0.5
	Carbofuran (Furadan)	-	1.0
	Phorate (Thimet)	30	1.0
	Carbaryl (Sevin)	-	1-2.0
	Toxaphene	28*	2.0
	Trichlorfon (Dylox)	28	1.5-2.0
	Fensulfothion (Dasanit)	30	0.75-1.0
	Bacillus thuringiensis (Thuricide)	-	7-14

*Do not feed ensilage to dairy animals or animals being finished for slaughter

In addition to the insecticides listed in Table 7, Penncap-M has 24(C) registrations in Iowa, Illinois, South Dakota, North Dakota, Kansas, Kentucky, Maryland, New

Jersey, Delaware and Texas. The material was used extensively in Iowa in 1978. It was credited with bee kills and the Iowa Department of Agriculture initiated action via its rule making authority to withdraw the 24(C) or restrict its use on fields that were actively shedding pollen. It will be included in further discussions as a material for use against corn borers, but legal restrictions may remove it as an alternative for this use, at least in some states.

Although ten materials are listed in Table 7, five of these either have never been used or have not been used to control European corn borers for over five years.

- Sevin - both 10% and 20% granules are registered. The 20% granules have not been made for several years and the 10% granules are made for and used primarily to control turf insects (139).
- Toxaphene - Efficacy data (14) show that other materials are better. Dealers also are reluctant to stock a product that can only be used to control one insect. Toxaphene is now in RPAR process.
- Dylox - The five percent Dylox is effective and although labeled, it never was made available for use (57). Since 30 to 40 pounds of product/acre are required, it would not be popular with the aerial applicators. Dealers would also be reluctant to have it on hand because of limitedlabeling.

- Dasanit - It is registered for control of second generation only. Dasanit has no other uses and is not distributed in a large segment of the corn belt (57). Most control for corn grown for grain is directed against the first generation.
- Thuricide - Bacillus thuringiensis formulations have been evaluated for many years (137). Although some control results have been satisfactory (101), other test results have been poor (96). The product has never been available in the corn belt. Tests have shown that granules are better than sprays (94,95), but the shelflife of granules is poor. A product that would not be used in the year it was purchased would not be effective the following year.

Listed in Table 8 are the results of research (14a) comparing most of the registered insecticides to control corn borers. The insecticides were applied with ground equipment and laboratory reared egg masses were artificially used to infest the plants in this study. Artificially infesting the plants with four egg masses insures that the insecticides are challenged. However, in tests of this nature, the timing of the insecticide application is perfect so that tests designed in this manner will often indicate better control than in experiments that use natural infestations and where aircraft is used to apply the insecticides.

- Furadan - It is registered for control as second generation only. Benefit has not [illegible] and is not distributed in a large segment of the corn belt (57). Most control for corn grown for seed is [illegible] against the first generation.

- Thuricide - Lactillus thuringiensis formulations have been evaluated for many years (37). Although some control results have been satisfactory (10[illegible]), other test results have been poor [illegible]. The product has never been available in the corn belt. Data have shown that granules are better than sprays (34,35), but the shelf life of granules is poor. A product that would [illegible] be used in the year it was purchased would not be effective the following year.

Listed in Table 9 [illegible] the results of research [illegible] comparing most of the registered insecticides on [illegible] corn borers. The insecticides were applied with ground equipment and laboratory reared egg masses were artificially used to infest the plants in this study. Artificially infesting the plants [illegible] that the insecticides are challenged. However, in tests of this nature, the timing of the insecticide application is perfect so that results obtained in this study will [illegible] indicate better control than in experiments that [illegible] natural infestation and where aircraft is used to [illegible] the insecticides.

Table 8. Effectiveness of Insecticides Against First and Second Generation European Corn Borer, Ankeny, Iowa, 1973.

Treatment	Formu-lation	AI Acre	Cavities/20 plants First Generation	Cavities/20 plants Second Generation	% Control First Generation	% Control Second Generation
Test 1						
Dyfonate	20G	1.0	25.8	13.8	71	67
Dylox	5G	1.5	12.0	19.0	86	55
Furadan	10G	1.0	27.5	17.3	69	59
Dasanit	15G	0.75	28.5	21.0	68	50
Toxaphene	10G	2.0	30.5	17.0	65	60
Sevin	10G	2.0	26.3	21.3	70	50
Diazinon	14G	1.0	26.3	21.0	70	50
Untreated			88.4	42.3		
Test 2						
Diazinon	14G	1.0	21.3	13.3	72	64
EPN	4G	0.5	33.5	15.3	56	58
Toxaphene	15G	2.0	39.0	14.0	49	62
Untreated			76.5	36.5		

In Iowa in 1978, both first and second generation populations were high and Dr. Berry was able to conduct some tests using a commerical airplane applicator to apply the insecticides. The results of several of these tests are reported in Table 9 (13).

Table 9. Aerial applications to control corn borers in Iowa in 1978.

Insecticide	Date of Application	Rate	Cavities Per Plant	Percent Control
First Generation				
Furadan	July 3	1.0	0.4	91
Thimet	July 3	1.0	1.5	65
Untreated			4.2	
Second Generation				
Furadan	August 12	1.0	12	0
Penncap-M	August 12	1.0	9	25
Untreated			12	
Penncap-M	August 12	1.0	5	44
Untreated			9	

The very poor control obtained against the second generation is because eggs were laid during the entire month of August. During August, larvae in all stages of development were present. Under these conditions, it is impossible for a single application of any insecticide to control the corn borer. Under conditions of continuous egg laying, it would be necessary to use two to three insecticide applications to obtain satisfactory control (14).

Availability Determines Use

Furadan 10G, Dyfonate, 20G and Thimet 15G are all used as planting-time applications to control corn rootworms. All of these products are readily available in

distributor and dealer channels throughout the corn belt. If corn borer populations reach economic levels, one of these three readily available insecticides are used. Penncap-M is registered and used in the midwest to control alfalfa weevil, grasshoppers and greenbugs and is readily available to use to control corn borers.

Other insecticides that may be as effective and nearly equivalent in cost are at a very real disadvantage in the market place. In order to keep chemical inventories down and reduce the chances of having a large inventory of a pesticide that was not needed, materials such as EPN 2G and 4G and Diazinon 14G are not stocked.

Table 10. Insecticides and their per acre costs for use on European corn borers (155).

Insecticide	Range	Recommended or Most Commonly Used Rate (AI/Acre)	Cost of product/ lb.	Material Cost Acre	App. Cost Acre	Total Cost Acre
Furadan	1	1	0.85	8.50	3.50	12.00
Dyfonate	1	1	1.30	6.50	3.50	10.00
Thimet	1	1	0.77	5.15	3.50	8.65
Penncap-M	1	1	14.75/gal.	7.37	3.50	10.87
Diazinon	1 to 2	1	1.24	8.68	3.50	12.18
EPN	0.2 to 0.5	0.5	0.57	7.12	3.50	10.62

Table 10 shows that the insecticide cost per acre of the four insecticides (Furadan, Dyfonate, Thimet and Penncap-M) currently used to control European corn borers ranges from \$5.15 for Thimet to \$8.50 for Furadan. The cost for EPN would be \$7.12 and Diazinon \$8.68. All six materials are similar in efficacy and costs are relatively similar.

directions and dealers [illegible] must the corn belt.

[illegible] corn [illegible] populations reach [illegible] levels, [illegible] these three credit, [illegible] [illegible] M is registered and used in the midwest [illegible] weevil. [illegible] able to [illegible] corn borers.

[illegible] insecticides that [illegible] most [illegible] market place. [illegible] corn [illegible] the [illegible] of a pesticide that was not [illegible] and [illegible]

[illegible]
Recommended
Max. Commodity
Use Rate
(AI [illegible])

Table 10 shows that the insecticide cost per [illegible] of the four insecticides (Furadan, Dyfonate, Thimet and [illegible]) [illegible] used to [illegible] European corn borers ranges from [illegible] Thimet Furadan [illegible] The cost for [illegible]

Application Techniques

Corn borers - When corn borer treatments are applied for the first-generation control, they are applied when the plant is in the pre-tassel stage. Most applications are granular insecticides applied by aircraft.

Application Equipment

Nearly all of the insecticides applied for European corn borers are applied by fixed wing aircraft. The capacity of the planes ranges from 1,000 pounds to 2,500 pounds, but most are 1,200 pounds or 150 gallons.

The operators estimate treating about 100 acres/hour or 1,000 acres per day. The standard application charge is $3.50/acre for all granules and for liquids requiring three gallons or less per acre.

Gloves, respirator and goggles are standard equipment used by all of the personnel assigned to loading planes or handling the insecticides. Although some automatic loading equipment is in use, much of the loading is done by hand. The granular insecticides used for corn borer control are available in 50 pound bags. Approximately five minutes would be required for loading.

Flagging is either done by use of an automatic flagger or by use of a vehicle, which is usually a pickup truck.

Table 11 shows that the number of acres that could be treated per load ranges from 75 acres using Penncap-M up to 240 acres for Dyfonate.

Table 11. Total Cost per Acre and Number of Acres One Load can Treat (1200 pound capacity).

Insecticide	Total Cost Per Acre	Lbs/Product Per Acre	Acres/Load Common Aircraft 1200/lbs. cap.
Furadan 10G	12.00	10	120
Dyfonate 20G	10.00	5	240
Thimet 14G	8.65	6.7	179
Diazinon 14G	12.18	7	171
EPN 4G	10.62	12.5	96
Penncap-M (2lb/gal)	10.87	2 qt + 1.5 water	75

b. Rootworm Beetles

Even though rootworms are present every year, most fields have pollinated by the time peak beetle populations are present. For these reasons, the number of acres treated for beetle control to prevent silk clipping is relatively few.

There are a number of insecticides registered for adult beetle control and are listed in Table 12.

Table 12. Insecticides Used to Control Corn Rootworm Beetles

Insect	Insecticide	Minimum Days Last Application to Harvest	Pounds of Active Ingredient to Apply/Acre
Corn rootworm beetles	Diazinon	--	0.25-0.5
	Malathion	5	1.0
	Carbaryl	--	1.0
	Sevin 4-Oil	--	1.0
	EPN + methyl parathion	14	0.1875+0.1875
	Imidan	14	0.25-0.5
	Parathion	12	
	EPN	14	0.25-0.5

An exception year was 1977. Rootworm development was earlier than normal, and adult emergence took place about the time many fields were beginning to pollinate. Many fields were treated although the actual number of acres treated is unknown.

Table 13. Insecticides and Their Cost for Rootworm Beetle Control

Insecticide	Range	Used Rate	Cost/ Lb.	Material Cost/Acre	App. Cost Acre	Total Cost Acre
Diazinon	0.25-0.5	*	7.60	1.90-3.80	3.50	?
Malathion	1.0	1.0	5.56	5.56	3.50	9.06
Carbaryl:						
Sevin 805	1.0	1.0	3.14	3.14	3.50	6.64
Sevin 4-Oil	1.0	1.0	3.67	3.67	3.50	7.17
Imidan	0.25-0.5	*	2.04	1.02-2.04	3.50	?
Parathion	0.25	0.25	2.50	0.75	3.50	4.25
EPN	0.25-0.5	0.25	5.70	1.42	3.50	
EPN+methyl parathion	0.1875-0.1875		9.33	1.55	3.50	

*Not used enough to know use rate.

Since the pollination period is short, protection from the silk-feeding beetles is only needed for a few days. All of the insecticides listed in Table 9 should give an adequate reduction of the beetle population so that pollination could occur. An insecticide with a long residual would not necessarily be needed. The insecticide used then would be probably the one that was readily available and competitive economically. EPN should compare favorably for this market, but it has been a small market except for 1977. The cost of the insecticides to control rootworm beetles is shown in Table 13.

Adult Corn Rootworm Management

This method of controlling rootworms is quite new and is used only on a few farms at this time. It involves counting the beetles weekly, from emergence through August. If beetle numbers reach the economic threshold of one beetle per plant, the adults are sprayed. This concept should not be confused with "silk-clipping" discussed above. The corn rootworm management method kills the beetles before the eggs are laid so beetle control substitutes for larval control the following year. An insecticide that would have the longest residual activity is used so that beetles that emerge later or migrate into the field later will be killed by the one application.

Because Sevin 4-Oil has the longest residual activity (two to three weeks) (162), it has been used almost exclusively in any adult corn rootworm management programs. This program does require that beetles be counted weekly and requires a well-trained scout. Post-spray counts are needed so that the grower can confidently substitute adult control for larval control. EPN would not fit in this program because of its short residual activity.

... [illegible] ...

[illegible] of [illegible] [illegible] is quite new and is used [illegible] [illegible] of this [illegible]. It involves counting the [illegible] weekly, [illegible] through August. [illegible] numbers reach [illegible] of [illegible] beetle [illegible] [illegible] [illegible] contact [illegible] not [illegible] confused with "[illegible]" [illegible] [illegible] [illegible] [illegible] while the [illegible] before the [illegible] [illegible] [illegible] control [illegible] [illegible] control the [illegible] year. [illegible] [illegible] [illegible] signal activity [illegible] [illegible] that beetles the [illegible] later or [illegible] [illegible] the [illegible] by the one application.

Because Sevin [illegible] the longest [illegible] activity (due to [illegible] [illegible]), it [illegible] [illegible] most exclusively in an adult [illegible] [illegible] program. This [illegible] requires that [illegible] weekly and requires a [illegible] [illegible]. [illegible] counts are needed so that [illegible] substitute adult [illegible] [illegible] [illegible] not fit in this program because [illegible] [illegible] mention.

SEED CORN

The majority of the seed corn is produced in the states of Iowa, Illinois, Indiana, Ohio, Nebraska, Minnesota and Wisconsin (12). The seed yield of single cross inbred lines will range from ten to 50 units[1] per acre (12). Depending on planting rate, each unit will plant three to four acres. Assuming an average yield of 30 to 35 units per acre of seed, it would require about 3/4 million acres of seed to meet the planting needs of corn growers in the U.S. each year (12). In years (like 1979) when seed yields were above normal, the seed is carried over to the next year with fewer acres planted the following years.

It is difficult or impossible to obtain the genetic pedigree makeup of individual corn hybrids. Production and value figures are also not readily available. For this report, an approximation of the production and value of the seed industry is shown below.

20 million bags or units needed to plant 80 million acres

x $50

$1 billion retail value of seed

x .15 - estimated amount paid by companies to growers to produce seed

$150 million (or $200 per acre - based on 3/4 million acres)

Seed fields are subject to attack by the same insects that attack field corn. Because of the higher per acre value of the seed crop and because of the less vigorous seed plant, insecticides are used on a much higher percentage of seed corn than on field corn. Seed fields are monitored closely by trained personnel and insecticides are applied at lower insect thresholds than field corn, e.g., seed fields are treated for first generation corn borer control when 25% of the plants are infested, as opposed to 35-50% infestation for field corn. In addition, a second

[1] A unit is a bag containing approximately 80,000 seeds.

application may be applied seven to ten days later on seed fields if feeding continues, whereas a second application would rarely be applied to field corn.

Because of the higher value of the crop, one to two insecticide applications may be applied for second generation control on seed fields. Since the efficacy is lower for second generation, field corn is rarely treated for second generation control.

Seed companies are very interested in the residual activity and reentry intervals of granular insecticides because detasselers and roguers may need to enter fields shortly after insecticide applications. They will sometimes need a short-lived compound or a safe compound if detasseling operations are needed soon after insecticide treatments.

Although reentry periods are not indicated on many of the granular insecticides used for corn borer control, seed companies do not want to send detasselers into fields recently treated with Dyfonate, Furadan, Thimet or EPN. Diazinon 14G is used or has been used some by the seed corn industry, but it is not always available. An attempt was made in Iowa in 1979 to obtain a 24(C) label for Lorsban 15G so that an effective and safe corn borer control material would be available to the seed industry. The 24(C) label was not approved and this need still exists.

Detasseling is done by crews walking through fields or by riding on machines. In addition, some detasseling is done by cutting off the top portion of the plant with machines or by machine "pullers".

Many inbred lines are notoriously poor "pollinators" and will not tolerate much beetle silk slipping. Because of this failure, the threshold for beetle control to prevent silk clipping is much lower. Therefore, a higher percentage of seed fields are treated each year for beetle control than field corn.

SWEET CORN

Sweet corn is grown over a wide area of the United States. The production figures of sweet corn grown for the fresh market and for processing are shown in Table 14 (167a).

Table 14. Acres of Fresh Market and Processing Sweet Corn for 1976, 1977 and 1978.

	Acres				
Sweet Corn	1976	1977	1978	3 - yr. Ave. Acres	3 - yr. Ave. Prod.
Fresh Market	179,500	169,900	170,000	173,133	13,614
Processing	460,980	453,980	429,610	448,190	2,346,083 Tons
	640,480	623,880	599,610	621,323	3,026,767 Tons

Fresh market sweet corn plantings are somewhat staggered in each growing area so that fresh sweet corn is available over as long a period as possible. Processing sweet corn also utilizes staggered planting so that the pack season is as long as possible.

Ear attacking insects, such as the European corn borer and the corn earworm, are the most important insect pests of sweet corn. Corn rootworm larvae can cause damage, but usually these insects are controlled culturally. Fields on which early to mid-season sweet corn was grown can have the stalks disked immediately after harvest. Rootworm beetles will not lay their eggs in fields treated in this manner. Often this can occur before rootworm egg laying takes place so fields can be planted to sweet corn the following year without a need for rootworm larval insecticide. Or, sweet corn is planted on fields that were planted to a different crop the previous year so rootworms would not be present.

The earliest plantings of sweet corn in an area are likely to be infested with first generation corn borers in some years. The mid-season to late-season sweet corn would likely be attractive to late generation corn borers.

From the silking to harvest, both fresh market and processing sweet corn receives repeated applications of insecticides that are applied to keep corn borers and corn earworms from infesting the ears. Because EPN has a 14 day harvest interval, it is not used for this purpose. Sevin 80S and methomyl are currently being used for this late-season insect control (33). Penncap-M is competitive from a cost comparison, but it is no more effective than methomyl or Sevin and because of the problem of bee kills and resulting feuds with beekeepers, Penncap-M is not an alternative for the large processing companies (91,136,185).

The insecticides suggested for use on sweet corn for European corn borer control are listed in Table 15.

Table 15. Insecticides Suggested in USDA Guidelines to Control European Corn Borers (166).

Pest	Insecticide	Min. Days from Last Application To Harvest	Pounds of Active Ingredient To Apply
European corn borer	carbaryl	0	1 to 2
	diazinon	-	1
	EPN	14	0.2-0.25
	methomyl	0	0.225-0.9
	ryania*	Exempt	1.2-1.6
	Penncap-M**	3	0.5-1.0

*Product discontinued by S. B. Pennick

**Not listed in the USDA guidelines

[illegible] rils ; plantings of sweet corn in an area are likely to be [illegible] with first generation corn borers in some areas. The mid-season [illegible] sweet corn would likely be attractive to late generation [illegible]

[illegible] the silking to [illegible] both fresh market and processing sweet [illegible] receives repeated applications of insecticides that are applied to [illegible] corn borers and corn earworms from infesting the ears. [illegible] 19 day harvest interval, it is not used for that purpose. [illegible] myl are currently being used for this late-season insect control. Penncap-M is competitive, from a cost comparison, but it is no more [illegible] than methomyl or Sevin and because of the problem [illegible] bee kills resulting lately with beekeepers, [illegible] processing companies (91,125,132).

The insecticides suggested for [illegible] for European corn [illegible] control are listed in Table 15.

[illegible] 5. Insecticides Suggested in USDA Guidelines [illegible] Control European [illegible] Corn Borers (156).

Insect	[illegible]	[illegible]	[illegible]
Corn borer	carbaryl	[illegible]	1 to 2
	diazinon	[illegible]	[illegible]
	EPN		

The retail cost of these materials applied at the rates indicated in table 15 are:

carbaryl (Sevin 80S)	3.15 - 6.30
diazinon	8.68
EPN	2.85 - 3.56
methomyl	2.96 - 11.85
ryania	3.65 - 4.86
Penncap-M	3.68 - 7.37

EPN is the most economical material listed and Rebuttal Letters numbers 15 (97a), 23 (143a) and 45 (140a) indicate that the product is the most economical and effective material to use for early season European corn borer control. The need for first-generation control in sweet corn will vary, depending on the size of the moth flight and the factors that affect corn borer populations. In some years, in some regions, first generation corn borers would not have to be controlled. In years when the factors that affect corn borer populations are favorable to the corn borer, there would be a definite need to control them to avoid losses.

The cost of diazinon would eliminate it as alternative, unless no other product was available.

4. Role of RPAR'd Pesticide

a. State Recommendations for control of corn insects:

State	Insect	Formulation	AI/A
Arkansas	European corn borer	4G	0.4
Colorado	Corn leaf aphid, armyworm, fall armyworm, cutworms	3+3 EC/EPN/M. Parathion	0.1875-0.28
	rootworm beetles	3+3 EC EPN/M. Parathion	0.1875
		4EC EPN	0.25-0.5
	western cutworm	3+3 EC EPN/M. Parathion	0.1875
Iowa	European corn borer	4G	0.5
	rootworm beetles	4 EC EPN	0.25-0.5
		3+3 EC EPN/M. Parathion	0.1875

[illegible]

[illegible] is the most economical material [illegible] [illegible] 25 (97a) [illegible] [illegible] economical and effective material to use [illegible] pean corn borer control. The need for first-brood [illegible] control in [illegible] will vary, depending on the size of the [illegible] and [illegible] that affect corn borer populations. In [illegible] years, it [illegible] [illegible]s, that generation corn borers would not have to be controlled [illegible] s when the factors that affect corn borer populations are [illegible] to the corn borer, there would be [illegible] need to [illegible] to avoid losses.

The cost of diazinon would [illegible] an alternative [illegible] [illegible] product was available.

[illegible] of [illegible] Pesticide

[illegible] are Recommended for control of [illegible]

Insects		
European corn borer	[illegible]	[illegible]
Corn leaf aphid, [illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

State	Insect	Formulation	AI/A
Kansas	rootworm beetle	4 EC EPN	0.25
	European corn borer	4G	0.4
		4 EC EPN	0.5
Montana	rootworm beetle	4 EC EPN	0.25
Nebraska	rootworm beetle	4 EC EPN	0.25
	European corn borer	4G	0.3
Wyoming	rootworm beetle	4 EC EPN	0.25-0.5

b. Review current Pest Management Program

Integrated pest management is in the beginning stages of development in the corn belt. More pest management firms are being established each year and established firms are expanding. The percentage of corn acres that are in a modern IPM program is at this time very small.

The IPM programs on corn emphasize monitoring for cutworm damage in May and monitoring rootworm beetles in July and August. Monitoring for corn borers is also included in the IPM programs, but the emphasis in getting farmers to get into IPM programs are cutworms and beetles, as they are not as sporadic as corn borers.

However, insecticide use to control European corn borers and rootworm beetles have never been on a calendar or regular treatment basis. As mentioned earlier, corn borer populations are influenced by many interrelated factors. Since populations are not consistently high enough to be at economic levels each consecutive year, growers have never conditioned themselves to treat on a regular basis every year. They have learned to recognize larval leaf feeding and use insecticides when infestations warrant treatments.

Corn rootworms are more consistently economic on corn following corn acres. However, the main thrust of rootworm controls are directed toward larval control, and EPN is not registered for this use.

[illegible] Pest Management Progr[illegible]

Integrated pest management is in the beginning stages of deve[illegible] in the corn belt, [illegible] pest management [illegible] being [illegible] year and established firms are stimulating [illegible] that [illegible] a model IPM program [illegible] this time only would.

[illegible] IPM programs on co[illegible] monitoring of [illegible] and monitoring rootworm beetles in July and August. [illegible] corn borers are also included in the IPM programs, but [illegible] farmer to [illegible] IPM programs [illegible] and because they are not as [illegible] borers.

[illegible], insecticide use to control European corn borers and [illegible] have never been [illegible] regular treatment [illegible] mentioned earlier, [illegible] populations are [illegible] factors. Since population [illegible] are not consistently high [illegible] be at [illegible] levels each consecutive year, [illegible] to treat on a regular [illegible] year.

[illegible] d to recognize [illegible] and use insecti-

[illegible]

[illegible] are most commonly encountered in corn fertility [illegible]

[illegible] the main thrust of [illegible] concerns are [illegible]

EPN is registered for rootworm beetle control and it is one of several insecticides that competes for this relatively small market.

EPN also competes for the even more erratic need to control armyworm and fall armyworm infestations. It was used in 1978 in the corn acres in the southeastern region when a prolonged and serious fall armyworm outbreak existed. It was used because it was effective and available in dealer and distributor channels. Supplies of EPN and other registered materials were used extensively and nearly exhausted existing supplies (159).

5. Information on Other Registered Pesticides Used for Corn

Granular formulations of six insecticides currently compete for the large corn rootworm larval market. Nearly 6.5 million acres are treated each year in Iowa. The other major corn growing states treat a similar percentage of their corn acres with these same materials. Three of these granular insecticides are also registered to control European corn borers should economic populations of corn borers exist. This places Dyfonate 20G, Furadan 10G and Thimet 15G at an advantage over other insecticides that are only used in the midwest to control corn borers. Corn borer populations are sporadic, so the need to use insecticides to control them is sporadic. Many dealers have purchased granular formulations of toxaphene, diazinon, Sevin and EPN anticipating economic infestations of corn borers during the upcoming season. Often, expected corn borer populations did not materialize and their inventory of these granular insecticides were on hand for possibly two to five years. Dealers who have had this experience will not even consider stocking these materials again. These same dealers will often have some of the granular rootworm insecticides left over. If needed for corn borers, they are readily available. This is why materials such as EPN 4G and diazinon 14G are not at the present time being used extensively to control European corn borers on field corn.

Table 16. EPN use on corn (field, seed, sweet)

Corn Insects:

Corn rootworm adults (*Diabrotica sp.*)
European corn borers (*Ostrinia nubilalis*)
Armyworms
Spider mites
Aphids, thrips
Fall armyworms
Cutworms (climbing)
Stinkbugs
Cutworms (surface feeding)
Twospotted spider mite

Label Directions:

Apply 5 to 12.5 lbs 4% or 10 to 25 lbs 2% EPN granules using aerial or ground equipment. Apply 0.25 to 0.5 lb ai/acre of EPN as a foliage spray. Apply 0.25 - 0.5 lb/ai/acre EPN when in 3 + 3 methyl parathion ane EPN combination. Apply 0.125 - 0.5 lb/ai/acre EPN when in 4 + 2 EPN and methyl parathion combination. Apply 0.5 lb/ai/acre EPN when in 6 + 2 toxaphene and EPN combination. Do not apply within 14 days of harvest. Workers entering fields within 24 hours of application should wear protective clothing.

Parameters for control of insect pests in corn:

Formulations	2% granules, 4% granules 4 lb EC 2 lb EC 3-3 EC methyl parathion/EPN 4-2 EC methyl parathion/EPN 6-2 EC toxaphene/EPN 25% WP	
Packaging	5 gal; 50 lb bag	
Equipment	Aerial, ground application	
EPN applied by air	over 95% (estimated)	
Dosage of EPN	EPN European corn borer, adult corn rootworm beetles	0.2-0.5 lb ai/acre
	3-3 methyl parathion & EPN	
	Climbing cutworms, corn lead aphids, corn rootworm (adults), Fall armyworms, stinkbugs	0.1875 lb ai/acre
	Armyworms European corn borers	0.25-0.2816 lb ai/acre
	4-2 methyl parathion & EPN	
	European corn borers	0.25-0.5 lb ai/acre
	6 + 2 Toxaphene & EPN	

	European corn borers twospotted mites, thrips serpentine leaf miner, armyworms, climbing and surface cutworms	0.5 lb ai/A

Carrier	2 and 4% - clay granules EC - water
# of applications	Field corn - 1-2 per season (2 applications rarely applied to field corn) Sweet & seed corn - 1-3 per season

Season European Corn Borer	Field corn - 1st generation	- when 35-75% of the plants show evidence of leaf feeding; mid-May in southern Missouri, mid-June in central Iowa and late June - early July in central Wisconsin. Repeat 7-10 days if feeding continues.
	2nd generation	- at pollen shed when eggs begin to hatch; from July 15 through August 25.
	Seed corn - 1st generation	- when 25% of plants show leaf feeding. Repeat in 7 days if feeding continues.
	2nd generation	- at pollen shed when eggs begin to hatch.
	Sweet corn - 1st generation	- when 25% of plants show leaf feeding and continue at 5 day intervals as long as leaf feeding is evident.
	2nd generation	- apply when eggs begin to hatch.
Stage of growth	1st generation	- 30" extended leaf height to tassel
	2nd generation	- early to late pollen shed
Adult rootworm beetles		silking and pollination

	Granules	Spray
Vol finished spray/acre	5-25 lbs.	2-3 gals/acre
Average load capacity	1200 obs	150 gals
Speed of application	100 MPH	100 MPH
Boom width	~50'	~50'
Droplet size	-	
# hours/day suitable for spraying	10	6
# hours actual spraying	6	4
Average # acres treated/hr	100*	100
Refill time	5 minutes*	5 minutes

	Granules	Spray
Nurse tank (if used)		1200-1600 gal
Capacity of transfer system		150-200 gals/min
Avg # of acres of corn/farm		
#lbs of EPN	data not available	
# acres treated	data not available	
% of crop treated	data not available	
# applicator (aerial)	100 (Iowa)	
# mixers/loader	1 per applicator	
# flaggers	0 (automatic)	

References
*Estimated by Leo Sterk, Laverty Sprayers, Indianola, Iowa.

[illegible]

SECTION 4 - MINOR USE -- VEGETABLE CROPS

EPN is registered for control of several highly injurious pests attacking some important vegetables. Most important of these are beans, lettuce and tomatoes. The 1978 Agricultural Statistics publication (167) reported these crops were valued at $1,979,722,000 in 1977. These crops are produced generally throughout the U.S. but commercial production is more localized.

Aphids, armyworms, bollworms, serpentine leafminers, spider mites, lygus bugs and stink bugs are the most important pests attacking these crops for which EPN is registered. However, because other insecticides are more generally available or equally or more effective, EPN is extremely limited in its use on vegetable crops. Nevertheless, this fact does not negate the value of EPN as an effective insecticide and usefulness as an alternative in case of the development of resistance or loss of pesticides in general use through regulation or marketing problems.

Aphids are economically important on most vegetable crops in most locations. Aphids usually occur in clusters, are individually small, variously colored, full bodied and slow moving. Spread from field to field usually occurs by flight of winged forms. They transmit virus disease such as mosaic and leafroll which reduce vigor and yield. Heavy populations are capable of killing plants, especially young seedlings. These insects do not lay eggs except in the fall for overwintering. However, in warm climates some species remain active continuously, giving rise to living young all year. A peculiarity of reproduction is that young are produced parthenogenetically.

Leafminers are destructive pests on many vegetable crops. They are especially destructive on tomatoes. These tiny insects burrow as

larvae between the upper and lower surfaces of leaves and sometimes in the rinds of fruit. The immature stages are well protected from insecticides. Timing of application for control of adults is essential unless systemic insecticides are used. Leafminers are prevalent wherever vegetable crops are grown and all planted acreage is potentially exposed.

Lygus bugs, _Lygus_ _hesperus_ or _L_. _elisus_, injure the growing parts of the beans by puncturing the tissue and sucking out the sap, causing blasted buds, flower drop and shriveled seeds. They may inject a toxin into the plant. Lygus bugs have a wide range of hosts, overwinter as adults and become active in the spring, depositing eggs in stems and petioles of host plants. There may be from three to five generations annually.

Lygus bugs are of particular importance on dry beans in California, affecting 90,000 acres, and 318,000 acres in Idaho (167). These insects are problems where beans are grown near alfalfa, moving into the beans when alfalfa is cut.

Vegetables grown for fresh market are usually fairly rapid turnover crops and although natural controls may be abundant, rarely do they keep the pest insects below the economic thresholds. With the possible exception of potatoes, little research has been accomplished in utilizing pest-management techniques on vegetables. FDA regulations limit the amount of insect debris allowable in food. Thus, high value crops such as tomatoes, lettuce, and beans are not allowed to tolerate even a low level of insect damage. However, with an increased emphasis and the accelerated research on resistant cultivars, this system may soon be incorporated into vegetable management programs so that less dependence will be necessary upon insecticides.

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lettuce, and beans are not allowed

damage. However, with an increased

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into vegetable

Table 17. Acreage of Three Major Vegetable Crops[1/]

	Acreage	No. of States Producing
Beans	690,000	14
Lettuce	224,000	6
Tomatoes	471,180	9

[1/] Data from Dimethoate National Pesticide Information Progress State Survey (172).

Table 18. Sites and Pests for Registered Uses of EPN.

Site and Pest	Dosage	Tolerances - Summary Usage and Limitations
Beans		3.0 ppm. 21 day preharvest interval through 0.5 lb./A. Foliage application.
Mexican bean beetle Twospotted spider mite Spider mites	0.13-0.5/A. (EC) 0.13-0.25/A. (WP)	Foliage application. For Mexican bean beetles, make 2-4 applications starting 5-7 days after eggs are laid.
Beans (Dry & Green)		
Armyworms (including southern and yellow stripped)	0.25-0.50/A. (EC, WP)	Foliage spray.
Potato aphid and aphids	0.25-0.50/A. (EC, WP)	Foliage spray.
Serpentine leafminer	0.25-0.50/A. (EC, WP)	Foliage spray.
Plant bugs (rapid and tarnished lygus)	0.25-0.50/A. (EC, WP)	Foliage spray.
Thrips	0.13-0.25/A. (EC, WP)	Foliage spray.
Mexican bean beetle	0.13-0.50/A. (EC, WP)	Foliage spray.
Leafhoppers	0.13-0.25/A. (EC, WP)	Foliage spray.
Beet webworm	0.25-0.50/A. (EC, WP)	Foliage application.
European corn borer	0.25-0.50/A. (EC, WP)	Foliage application.
Tomato fruit worm	0.25-0.50/A. (EC, WP)	Foliage application.
Flea beetles	0.25-0.50/A. (EC, WP)	Foliage application.
Stink bugs	0.25-0.50/A. (EC, WP)	Foliage application.
Bollworm	0.25-0.50/A. (EC, WP)	Foliage application. Green beans only.
Tomatoes		3.0 ppm. 3 day preharvest interval through 0.25 lb./A. Foliage application. 21 day preharvest interval from above 0.25 through 1.0 lb./A. Foliage application.
Serpentine leafminer Aphids, Armyworms Tomato russet mite, Tomato fruitworm (Bollworm), Twospotted spider mite, Spider mites, Thrips, Leafhoppers.	0.25-1.0/A. (EC, WP)	Foliage application. Repeat at 7 to 10 day intervals as needed.
Plant bugs, Tarnished and Rapid, Yellow striped armyworm, Tomato hornworm, Flea beetles, Darkling beetles, Psyllids, Beet armyworm, Beet webworm, Cabbage looper, Potato aphid, Southern armyworm	0.5-1.0/A. (EC, WP)	Foliage application.

Table 19. Tomatoes for Processing and Acres Treated with EPN (167a).

	Acres Harvest	Yield/ Acre Cwt	Value 1,000 Dollars	No. Acres Treated	No. Lbs. Used
Calif.	250,000	25.40	428,625	--	--
Colo.	750	10.80	523	--	--
Ind.	9,800	14.75	10,509	--	--
Md.	2,800	12.82	2,179	--	--
Mich.	6,100	18.61	7,753	--	--
NJ	7,000	14.00	6,880	--	--
N. Mex.	--	--	--	--	--
Ohio	18,700	18.68	23,684	--	--
Pa.	4,400	16.65	4,821	--	--
Tex.	2,000	8.70	1,081	--	--
Va.	3,600	11.93	3,024	--	--
Other states	6,580	14.95	6,481	--	--
United States	311,730	23,52	495,560	--	--

Table 20. Tomatoes for Fresh Market and Acres Treated with EPN (167a).

	Acres Harvest	Yield/ Acre Cwt	Value 1,000 Dollars	No. Acres Treated	No. Lbs. Used
Ala.	7,700	67.0	18,277	--	--
Ark.	3,100	130.0	11,798	--	--
Calif.	32,300	208.0	136,337	71*	55*
Ga.	2,300	81.0	4,241	--	--
Fla.	39,700	247.0	244,617	--	--
Ind.	1,900	140.0	4,655	--	--
Md.	2,500	90.0	4,230	--	--
Mass.	620	190.0	2,903	--	--
Mich.	3,700	100.0	9,287	--	--
NJ	6,600	80.0	14,573	--	--
NY	3,000	130.0	9,945	--	--
NC	1,700	140.0	4,546	--	--
Ohio	700	160.0	3,046	--	--
PA	2,200	130.0	5,720	--	--
SC	8,000	120.0	18,293	--	--
Tenn.	3,000	100.0	6,960	--	--
Tx.	6,000	77.0	9,239	--	--
Va.	2,600	125.0	5,785	--	--
Haw.	270	230.0	2,065	--	--
United States	128,310	174.0	517,769	--	--

*1978 data, 1979 data not available.

Table 21. Snap Beans for Fresh Market and Acres Treated with EPN (167a).

	Acres Harvest	Yield/ Acre Cwt	Value 1,000 Dollars	No. Acres Treated	No. Lbs. Used
Fla.	40,300	30.6	34,604	--	--
Calif.	3,700	83.0	18,233	1,460*	866.8*
Ala.	1,200	30.0	1,472	--	--
Ga.	5,400	28.9	4,899	--	--
Mo.	1,900	26.8	1,015	--	--
Mich.	2,900	28.0	2,074	--	--
NJ	5,560	31.5	4,858	--	--
NY	6,100	36.0	6,474	--	--
NC	6,400	30.8	5,401	--	--
Ohio	900	35.0	925	--	--
PA	620	53.0	779	--	--
Tenn.	1,600	38.0	1,653	--	--
VA	4,100	28.9	2,927	--	--
United States	285,220	2.70	117,639	--	--

*1978 data, 1979 data not available

Table 22. Snap Beans for Processing and Acres Treated with EPN (167a).

	Acres Harvest	Yield/ Acre Cwt	Value 1,000 Dollars	No. Acres Treated	No. Lbs. Used
Calif.	7,300	1.91	2,872	--	--
Colo.	1,500	3.53	668	--	--
Del.	4,900	2.49	2,062	--	--
Fla.	13,500	2.44	4,875	--	--
Ga.	790	2.00	291	--	--
Ill.	9,500	2.99	3,949	--	--
Ind.				--	--
Md.	8,600	1.82	2,645	--	--
Mich.	17,300	2.08	5,829	--	--
NJ	6,800	2.12	2,480	--	--
NY	45,600	2.33	17,106	--	--
NC	4,000	2.08	1,340	--	--
Okla.				--	--
Oreg.	38,400	4.49	26,208	--	--
Pa.	4,700	2.11	1,657	--	--
Tenn.	9,900	1.61	2,917	--	--
Va.	4,000	1.95	1,303	--	--
Wash.	2,100	4.14	1,383	--	--
Wis.	79,300	2.68	29,115	--	--
Other States	27,030	2.46	10,939	--	--
United States	285,220	2.70	117,639	--	--

Table 23. Lettuce for Fresh Market and Acres Treated with EPN (167a).

	Acres Harvest	Yield/ Acre Cwt	Value 1,000 Dollars	No. Acres Treated	No. Lbs. Used
Ariz.	45,600	196.0	99,011	--	--
Calif.	157,500	277.0	379,031	--	--
Colo.	6,000	200.0	10,217	--	--
Fla.	13,700	191.0	49,119	--	--
Mich.	1,500	170.0	5,228	--	--
NJ	3,000	178.0	3,814	--	--
N. Mex.	4,200	188.0	6,979	--	--
NY	3,600	195.0	8,424	--	--
Ohio	800	110.0	2,702	--	--
Tx.	5,200	184.0	14,212	--	--
Wash.	1,200	170.0	2,387	--	--
Wis.	1,100	215.0	2,015	--	--
Haw.	650	145.0	1,974	--	--
United States	259	247.0	576,741	--	--

Although EPN is registered for use on these vegetable crops, replies received for Pesticide Impact Assessment Survey (Ragsdale, 1980) (135) and personal communications with State liaisons (15,17,20,23,37,43,50,59,60,64,66 81,84,99,100,112,115,123,124,141,145,154,151,179,193) indicate that little, if any, is used for control of listed pests (Tables 19-23). In most cases, dimethoate is the preferred insecticide. Reasons indicated are greater availability of dimethoate in the market and dimethoate is as effective as EPN.

Nevertheless, EPN is considered effective for control of pests listed on these vegetable crops. Thus, a suitable alternative to currently used pesticides is available in cases where resistance may develop or for some unforeseen reason, the preferred pesticide is unavailable.

Applications for dimethoate (currently the choice pesticide for control of vegetable pests) are either by ground or aerial, but usually by ground equipment. The methods of application are the same using other insecticides.

All precautionary measures on labels must be followed when EPN is used. Generally EPN is short-lived on foliage, reentry and harvest intervals are reasonable.

ough FPT is registered for use on [illegible]

Pesticide Impact Assessment Program [illegible]

nications with State Liaisons (15,17,20, [illegible]

9,112,115 123 124,141 145 [illegible]

used for control [illegible]

te is the preferred insecticide. Because [illegible]

of dimethoate in the market and dimethoate is [illegible]

ess, FPT is considered effective [illegible]

crops. Thus, a suitable alternative [illegible]

e in cases where resistance [illegible]

n, the preferred pesticide is unavailable.

[illegible] for dimethoate [illegible]

Alternatives: Dimethoate is the pesticide of choice by vegetable producers. Other alternatives include malathion, diazinon, endosulfan and parathion.

SECTION 5 - MINOR USE -- AQUATIC FOR MOSQUITO CONTROL

EPN is registered for control of mosquitoes by mosquito abatement district personnel, public health officials and other trained personnel of other public mosquito control programs.

Mosquitoes are serious pests of humans and domestic animals worldwide. Some species are vectors of important human diseases: malaria, yellow fever, dengue and certain filariasis. There are no other known methods of transmission. However, because of effective mosquito control, these diseases have been greatly minimized on a worldwide basis. Nevertheless, they are still a serious problem in some areas of the world.

In addition to their importance as vectors of human diseases, mosquitoes are significant, nuisance pests of man and animals. Occasionally, populations of mosquitoes, especially the Salt marsh species, are so plentiful that humans and animals cannot remain in infested areas without physical protection, e.g. screening, etc. The actual physical biting and inhaling of mosquitoes by livestock in marshlands is known to have caused their deaths.

There are about 140 species of mosquitoes in North America. Their life cycles and habits may vary in some details, but in general they have many similarities. Many species overwinter in the egg stage, although some do survive the winter as adults or larvae.

Mosquitoes always develop in water which contain microscopic plants and animals that serve as the food source for the larvae. Eggs are laid on water or where water is likely to accumulate. Eggs of some species are deposited as a raft, e.g. <u>Culex</u>; or singly, e.g. <u>Anopheles</u>. The egg-to-adult time period can be very short, five to seven days, up to several weeks, dependent on species.

Mosquito abatement is most effective on a community-wide or large area basis. Satisfactory control depends on a knowledge of mosquito biology, breeding habits, life cycle, flight range, adult resting place and food preferences. Elimination of breeding site is fundamental in effective control. Under certain situations, natural control and water management are often possible. In areas where the above control techniques have not been effective, insecticide control becomes essential.

Chemical control of mosquitoes are generally conducted as the last alternative by abatement districts, with larvicide as the most common appraoch. Larvicides of choice include temephos, Flit MLO and occasionally, in nonfish bearing waters, chlorpyrifos. For control of adults, chlorpyrifos and malathion are the insecticides used.

EPN is currently registered for control of mosquitoes. However, contact with leaders in the fields of abatement districts (143,157) and research personnel of both state (103,105,153) and Federal agencies (25,186), indicate no known use of EPN in current control programs. In California (143) where mosquitoes have developed resistance to the organophosphate insecticides, it is known that cross tolerance to EPN was concurrently developed (192). In other sections of the country, it is expected that effective control with EPN is possible.

In southern states where flood water mosquitoes, _Psorophora_ _columbiae_ and _Anopheles_ _sp_. are problems, especially in rice fields, researchers are anxious to retain EPN as a viable alternative for the currently used insecticides. As a rule, the insecticide applied for rice water weevil control, carbofuran, is adequate to control these species (103). However, the development of resistance to a commonly used pesticide is well established and should not be overlooked.

Application: The application of EPN would not differ from that of currently used insecticides. Depending on the situation, aerially applied emulsifiable concentrate or granular formulations would be used. In residential areas, mist blowers and ground equipment would be applicable. Following of precautionary measures on the EPN label would be essential, especially personal protective equipment for the applicators.

Summary: EPN was evaluated and found to effectively control mosquitoes in the early-to-mid 1950's (143). Lack of proper formulation and other characteristics resulted in the use of other insecticides. Abatement of mosquitoes is generally conducted on a large area basis. Where insecticides are necessary, other materials are favored. Thus, EPN has no known current uses. In the dynamic area of insect control, the development of resistance to an insecticide is a continual probability, thus alternative insecticides are desirable and needed to protect humans from possible pestilence outbreak. EPN is a valuable alternative in the armory for emergency use if the need arises.

Appl. [illegible]: The application [illegible]

[illegible] used insecticides. Depending on the [illegible]

[illegible] table concentrate or granular formulation [illegible] be used

[illegible] areas, along flowers and ground [illegible]

[illegible] of precautionary measures [illegible] essential,

[illegible] personal protective [illegible] of the [illegible].

[illegible] [illegible]

[illegible] in the [illegible]

[illegible] characteristic [illegible]

[illegible] of [illegible] period.

[illegible] insecticides are [illegible]

[illegible] no known [illegible]

development of resistance [illegible] cultural

[illegible], thus alternative insecticides [illegible]

[illegible] possible [illegible]

[illegible]

SECTION 6 - PECANS

A. Minor Uses

1. Commodity Information

a. Geographic distribution - The pecan, <u>Carya illinoesis</u> Koch, is grown principally across the southern United States in a belt that includes Alabama, Arizona, Arkansas, Florida, Georgia, Louisiana, Mississippi, New Mexico, Oklahoma, South Carolina, and Texas. Pecans are also grown in California, Kentucky, Missouri, Nebraska, North Carolina, Tennessee, and Virginia (127).

b-c. Acreage - Production and Value. 1978 average (167).
The average commercial production exceeded 236 million pounds in 1977 with a value of over 136 million dollars, with Alabama, Georgia, Mississippi and Texas being the largest producing states. Georgia leads in production of improved varieties while Texas leads in production of native seedlings.

d. Cultural practices - To produce profitable crops, the pecan grower must adhere to cultural practices that promote tree vigor, stimulate fruiting, and minimize the damage caused by pests. For example, trees weakened by inadequate nitrogen fertilization and rank weed growth are more susceptible to damage by some leaf-spotting fungi. Conversely, too much nitrogen, which promotes season-long growth, can produce tender shoots that are highly susceptible to the scab fungus and pecan aphids. Many disease organisms thrive under conditions that favor summer growth flushes. Practices that

allow good air circulation such as wide spacing of trees, removal of lower limbs, and maintenance of low ground cover and hedgerows in summer facilitate disease and insect control.

Ground sanitation is partially effective against most fungus diseases because the overwintering stage can often be eliminated. Ground trash, such as broken limbs, shucks, and insect-infested nuts, should be removed from the grove during the winter. Disking to turn under trash is not advisable unless no other means of debris disposal is available.

2. Pest information

The size, quality, and yield of pecans are reduced by 20 or more species of mite and insect pests. These pest also reduce the vitality of pecan trees by causing damage to leaves, nuts, twigs, branches, bark and even roots. Insect losses, in spite of control measures, are estimated at 12% or over $10 million, annually. The growth of the pecan industry has brought new problems in controlling pests. Some species that were not commonly present have transferred to pecans from hickories and other plants.

Table 24 lists the currently registered uses for EPN to control pests of pecans. The greatest use of EPN is for control of the hickory shuckworm, *Laspeyresia caryana* (Fitch) and pecan weevil, *Curculio caryae* (Horn), the two most injurious insects attacking pecans, according to replies received from the Pesticide Impact Assessment Survey. (Replies listed on pages 107 and 108).

allows good air circulation such as wide spacing of trees, removal of lower limbs, and maintenance of low ground cover and hedgerows in [illegible] diseases and insect [illegible] demand [illegible] part [illegible] must [illegible] fungus diseases because the overwintering stage can often be eliminated. Ground trash, and broken limbs, [illegible] and [illegible] mummies, should be removed from the trees during the winter. Disking [illegible] [illegible] vitable units, [illegible] [illegible]

Pest Information

The size, quality and yield of [illegible] more species of [illegible] insects. [illegible] the vitality [illegible] by [illegible] damage [illegible] twigs, branches, bark and even roots. Insect losses, in spite of control measures, are estimated at 12% or [illegible] The growth of the [illegible] industry has brought [illegible] controlling pests. Some species that were not [illegible] present have transferred to pecans from hickories and other plant [illegible]

Table 24 lists the currently registered [illegible] control pests of pecans. The greatest use [illegible] of the hickory shuckworm, *Laspeyresia caryana* [illegible] weevil, *Curculio caryae* [illegible], the two most [illegible] attacking pecans according to [illegible] from the [illegible] Impact Assessment Survey. (Replies [illegible] on pages [illegible] and [illegible].)

Table 24. EPN use on pecans.

Pecan Insects:	
Spider mites	
Aphids	
Hickory shuckworm	
Pecan weevil	
Fall webworm	
Walnut caterpillar	
May beetles	
Fruit tree leafroller	
Pecan twig girdler	
Southern green stinkbug	
Dosage of EPN	
Spider mites (including Twospotted spider mite, Willamette spider mite)	0.125-0.20/100 gal. water (EC, WP)
Aphids (including Black pecan aphid, yellow pecan aphid) Mites (other than spider mites) Pecan nut casebearer	0.38-0.5/100 gal. water (EC, WP)
Hickory shuckworm Pecan weevil	0.42-0.5/100 gal. water (EC, WP)
Fall webworm Walnut caterpillar	0.42-0.5/100 gal. water (EC, WP)
May beetles	0.42-0.5/100 gal. water (EC, WP)
Fruit tree leafroller	0.38-0.50/100 gal. (EC, WP)
Pecan twig girdler	0.42-0.5/100 gal. water (EC, WP)
	0.5/100 gal. water (WP, EC)
Southern green stinkbug	0.42-0.5/100 gal. water (EC, WP)
Pecan leaf casebearer	0.38-0.50/100 gals. (EC, WP)
Spittle bugs	0.25-0.38/100 gals. (EC, WP)

Pest: Hickory shuckworm, Laspeyresia caryana (Fitch)

Hosts: The hickory shuckworm is one of the most destructive insects that infest the pecan.

Damage: Hickory shuckworms attack the nuts from about the first of June until harvest. From the time of first appearance until shell hardening late in August, these insects can continually destroy the interior of the nuts. Immature nuts infested early in the season fall to the ground. It is usually difficult to see the entry holes made by shuckworms except under magnification. Their presence, however, may often be detected in newly dropped nuts by a powdery white stain around the entry point. Much of the crop may be lost to shuckworms, especially when there is a light nut set.

After shell hardening, shuckworms tunnel in the green shucks and prevent the kernels from developing properly. Infested nuts may be poorly filled and may mature later than health nuts. Injured portions of the shucks stick to the nuts and interfere with processing, and the shells are often badly stained.

Pest Status: In northern Florida and southern Georgia, the moths begin to appear in mid-February, but most moths of the first generation emerge in April, and a few continue to appear well into summer. The spring development of the insect coincides with that of the native hickory nuts on which the early moths lay eggs. The hickories set fruit two to three weeks earlier than the pecan. The late-emerging moths of the spring brood lay their small, whitish,

? Hickory Shuckworm, *Laspeyresia caryana* (Fitch)

Hosts: The hickory shuckworm is one of the most destructive insects that infest the pecan.

Damage: Hickory shuckworms attack the nuts from about the first of June until harvest. From the time of [illegible] until shell hardening late in August the [illegible] usually destroy the interior of the nuts. Immature nuts infested [illegible] in the season fall to the ground. It is usually difficult to see the entry holes made by shuckworms except under magnification. Their presence, however, may often be detected in newly [illegible] by a powdery white stain around the [illegible] [illegible] the crop may be lost to shuckworms, [illegible] less high nut set.

After shell hardening, shuckworms tunnel in green shucks and prevent the kernels from developing properly. Infested nuts may be poorly filled and may mature later than healthy nuts. Injured portions of the shucks stick to the nuts and interfere with proper harvest, and the shells are often badly stained.

Pest Status: In northern Florida and southwest Georgia, the moths begin to appear in mid-March, but most moths of the first generation emerge in April, and a few continue to appear well into summer. The spring development of the insect coincides with that of the native hickory nuts on which the early moths lay eggs. The [illegible] The later [illegible]

[illegible]

flattened eggs on the foliage and small nuts of the pecan. Few pecan nuts become infested with shuckworms before June because most of the spring brood of moth dies before the nuts set. Starting in June, the shuckworm population increases rapidly, with as many as four or five successive generations found in southern Georgia.

Life History: Full-grown shuckworms overwinter in shucks on the ground or on the tree. They are one-third to one-half inch long and creamy to dirty white, with brownish heads. They pupate within the shuck in late winter and early spring and then metamorphose into inconspicuous moths, dark brown to smoky black, about three-eighths inch long, with one-half inch wingspans.

Distribution: Southeastern United States, west to Texas.

Nonchemical Control: Growers with few trees and those not equipped to spray may reduce infestation by gathering and destroying pecan shucks at harvest. Plowing the shucks under in early spring may aid control. The drops (small nuts) should be gathered and burned during midsummer.

The use of one blacklight trap for every three to five mature trees will also help to reduce the hickory shuckworm (147).

Alternative Chemicals:

Dialifor: For control of shuckworms, the rate of application is 0.5 pounds AI per 100 gallons of water as 1-2 pounds AI/acre. Do not apply more than 12 pounds AI per acre and do not apply the chemical after shucks have split. Do not graze livestock in treated groves. Also registered for control of pecan weevils, spittlebugs, pecan nut casebearer and pecan aphids.

on the foliage and small nuts of the trees.

d become infested with shuckworms before they produce most of the spring brood of moth which ... the nuts set. Starting in June, the shuckworm population increases rapidly, with as many as four or five successive generations found in southern Georgia.

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The use of one black light trap for every ... five mature trees will also help to reduce the shuckworm ...

ical: For control of

de A1 per 100 gallons of water ...

ve than 12 pounds A1 per acre and do not apply the chemical

... available. Do not graze livestock in treated ...

... control of pecan ...

Phosalone: The rate of application is 0.5 pound AI (1 1/3 pints Zolone[R] EC [3 lb/gal]) per 100 gallons or 1.0 to 2.0 pounds AI (2 2/3 to 5 1/3 pints Zolone EC) per acre. Apply the chemical as a complete cover spray. Do not apply more than 20 pounds AI (53 1/3 pints Zolone EC) per season. Do not apply after shucks have split and do not allow livestock to feed on treated cover crops or feed crop to livestock products containing phosalone. May also be used to control pecan aphids, pecan spittlebug, pecan nut casebearer (west south central states only).

Azinphosmethyl: The rate of application is 0.37 - 0.56 pounds AI per 100 gallons of water. Apply as a complete cover spray. Do not graze livestock in treated orchards. Do not apply after shucks have split. Do not apply in home plantings; should be applied only by a trained operator. Azinphosmethyl also may be used to control pecan spittlebug, southern green stinkbug, walnut caterpillar, pecan nut casebearer, mites, leafminers, fall webworm, pecan aphids.

Pest: Pecan Weevil, *Curculio caryae* (Horn)

Hosts: The pecan weevil attacks the pecan and hickory nuts.

Damage: Pecan weevils cause two kinds of nut damage, depending on the stage of nut development at the time of attack.

The first kind of damage is caused by adult weevils feeding on kernels in water stage, before shell hardening. This feeding generally results in a drop of all punctured nuts, but the infestation may pass unnoticed because other insects and factors can also cause a premature nut drop. Weevil-punctured nuts can be identified by a tobaccolike stain around the feeding site. Dark patches develop on the nut surface, and in a few days the nuts drop from the trees.

Phosalone: The rate of application [illegible]

lone EC [illegible] per 100 gallons [illegible]

5 1/3 pints Zolone EC) per acre. [illegible]

per spray. Do not apply more than [illegible] pints Zolone

season. Do not apply after shucks [illegible]

[illegible] feed [illegible] forage [illegible]

containing phosalone. [illegible]

[illegible], pecan [illegible]

Azinphosmethyl: The rate of application [illegible]

100 gallons of water. [illegible]

livestock in treated orchards. Do not [illegible]

[illegible] apply in home plantings; [illegible]

[illegible]. Azinphosmethyl also [illegible]

[illegible] green stinkbug, walnut [illegible]

[illegible], fall webworm, pecan [illegible]

Pecan Weevil, Curculio caryae (Horn)

[illegible]: The pecan weevil attacks the pecan and hickory [illegible]

[illegible]: Pecan weevils cause two kinds of nut damage, depending

[illegible] nut development at the time of attack.

First kind of damage is caused by adult weevils feeding on

[illegible] in water stage, before shell hardening. This feeding [illegible]

[illegible] in a drop of all punctured nuts, but the [illegible] may be

[illegible] because other insects and diseases can also cause [illegible]

[illegible]. [illegible]-punctured nuts can be identified by [illegible]

around the feeding [illegible]. Dark patches develop [illegible]

[illegible] days the nuts drop from the trees.

The second kind of damage is caused by weevil grubs, or larvae, feeding in the partially matured nuts. Damaged mature nuts bleed little and do not drop. The grubs feed on the kernels for several weeks. When fully grown, about three-fifths inch long, the creamy-white grubs with reddish-brown heads leave the nut through circular holes about one-eighth inch in diameter. Infested nuts are worthless since the larvae normally destroy the kernels, and the shucks often adhere to the shell. This damage is noticeable at harvesttime and may destroy practically the entire crop in seasons when large numbers of weevils are present.

Pest Status: The weevils do not ordinarily move far from the tree under which they emerge from the soil, provided there is a crop of nuts on that tree. Consequently, certain trees may be heavily infested year after year, while other trees of the same variety close by may receive little damage. Weevils apparently prefer trees growing in low areas and those adjacent to hickory trees.

Pecan varieties differ widely in their susceptibility to attack. Early-maturing varieties such as 'Mahan', 'Moneymaker', 'Schley', and 'Stuart' are most commonly infested. Late-maturing varieties such as 'Mobile', 'Teche', and 'Van Deman' are usually not attacked unless the crop of early-maturing varieties is light or destroyed before the insect completes feeding and egg laying. Most hickory nuts are attacked.

Adult weevils emerge from the soil at various times. In central Georgia, they usually emerge between August 1 and September 15, and in central Texas, in August or early in September after periods of heavy rainfall.

Life History: At the time of kernel formation near the end of August, the females drill holes through the shucks and shells with their long beaks and place two to four eggs in separate pockets within the kernels.

The second kind of damage is caused by weevils ... In the partially grown nuts. Damaged nuts ... do not drop. The grubs feed on the kernels ... ully grown, about ... inch long, ... crown heads ... in diameter. Infested nuts are ... the kernels, and the ... is ... at harvest ... the crop in seasons when ... States. The weevils do not ... they emerge from the soil, ... tree. Consequently, certain trees ... year, while other trees ... damage. Weevils ... those adjacent to hickory trees.

Pecan varieties differ widely ... turing varieties such as ... are most commonly infested. Late-maturing varieties ... ... 'Teche', and 'Van Deman' ... of early-maturing varieties is ... feeding and egg laying. ... Adult weevils emerge from the soil ... they usually emerge between August 1 and September 15 ... in August or early in September. ...

... time of kernel formation ... through the shucks and shells ...

Most grubs leave the nuts between the last of September and the last of December, but some may be later. They enter the soil to a depth of four to 12 inches and construct earthen cells, where they remain in the larval stage one or two years. They pupate between the first part of September and the middle of October and metamorphose into adults in about three weeks. These adults remain in the soil until the following summer. The complete life cycle requires from two to three years.

Distribution: New York to the Gulf states and west into New Mexico (271).

Nonchemical Control: Growers not prepared to spray and those with dooryard trees can reduce weevil injury by placing harvesting sheets under trees and lightly jarring the limbs to shake the weevils free. It may be necessary to climb the trees to reach upper portions. The dislodged beetles usually remain still and can be collected easily. They should be killed by crushing or by immersing in kerosene.

Begin shaking the weevils out of trees in early August in Georgia, Alabama, Mississippi, Louisiana, and North and South Carolina. Begin after the first heavy rain in mid-August or early September in Texas. This should be repeated weekly until about September 15 or until no weevils are recovered. To determine the presence of weevils, jar a few of the trees known to be the most heavily infested year after year. If the weather is dry, few weevils will be collected, and frequent shaking of trees is not necessary until rain softens the ground (174).

Alternative Chemicals: (See Table 25 - prepared by Jerry A. Payne, Member of Carbaryl Assessment Team)

Dialifor: For control of pecan weevil, the rate of application is 0.5 pound AI per 100 gallons of water or 1-2 pounds AI/acre. Do not graze livestock in treated areas. Do not apply more than 12 pounds

These grubs leave the nuts between the last of August [illegible]

[illegible]ember, but some may be later. [illegible]

[illegible] 12 inches and construct earthen cells, [illegible]

[illegible] stage one or two years. They pupate [illegible]

[illegible]tember and the middle [illegible] October [illegible]

[illegible] weeks. These adults [illegible]

[illegible] complete life cycle requires [illegible]

[illegible]tion: New York to the Gulf states [illegible]

[illegible]cal Control: Growers not prepared [illegible]

[illegible] trees can reduce [illegible] injury [illegible]

is not lightly jarring the limbs [illegible]

[illegible] necessary to climb the trees to reach [illegible] dislodged

[illegible] usually remain still [illegible]

[illegible] killed by crushing [illegible]

[illegible] begin shaking [illegible]

[illegible] Mississippi, Louisiana, and [illegible]

[illegible] the first heavy rain in mid-August [illegible]

[illegible] should be repeated weekly until [illegible]

[illegible] are recovered. [illegible]

[illegible] of the trees known to be [illegible] heavily [illegible]

[illegible] weather is dry, few [illegible]

[illegible] of trees is not necessary until [illegible]

[illegible] Chemicals: (See Table 25 - prepared [illegible]

[illegible] Chamber of Commerce [illegible]

[illegible]tion: For control of pecan weevil, [illegible]

[illegible] per 100 gallons of water [illegible]

[illegible] in grassed areas. Do not apply more than [illegible]

Table 25. Pecan acres grown, acres treated for pecan weevil with alternative chemicals and amount used per state.[1/]

State	Pecan acreage	Weevil infested acreage	Weevil treated acreage	Carbaryl treated acreage	Amount carbaryl used	Torak treated acreage	Amount Torak used	Zolone treated acreage	Amount Zolone used
Alabama	55,000	35,000	30,000	28,500	256,500	1,500	13,500	0	0
Arizona	14,063	0	0	0	0	0	0	0	0
Arkansas	9,000	6,500	3,000	2,250	22,950	0	0	450	1,350
California	200	0	0	0	0	0	0	0	0
Florida	12,000	7,200	3,600	2,520	22,680	1,080	6,480	0	0
Georgia	200,000	145,000	101,500	91,350	1,370,250	10,150	126,875	0	0
Kentucky	750	560	0	0	0	0	0	0	0
Louisiana	67,818	64,358	9,409	9,409	141,135	0	0	0	0
Mississippi	60,000	35,000	1,000	1,000	6,000	0	0	0	0
Missouri	26,378	26,378	264	264	3,960	0	0	0	0
New Mexico	14,063	0	0	0	0	0	0	0	0
N. Carolina	8,000	500	300	210		0	0	15	
Oklahoma	63,000	41,850	10,962	7,673	115,101	548	4,111	2,192	21,294
S. Carolina	10,000	9,500	4,750	3,800	28,500	0	0	950	7,598
Tennesse	150	150	60	30	150	0	0	0	0
Texas	800,000	510,000	260,000	260,000	4,062,500	0	0	0	0
Virginia	100	?	0	0	0	0	0	0	0
Total	1,340,522	881,996	424,845	407,006		13,278		3,607	

[1/] Information obtained by Jerry A. Payne, Reseach Entomologist, AR, Member Carbaryl Assessment Team.

Table 25 (Cont'd.)

Toxophene acreage	Amount toxophene used	Parathion acreage	Amount Parathion used	Guthion acreage	Amount Guthion used	Malathion acreage	Amount Malathion used
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
300	10,800	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	30		30		15	
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
6	180	9	36	9	54	6	15
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
306		39		39		23	

per acre per season. Do not apply the chemical after shucks have split. Also registered for control of hickory shuckworm, spittlebugs, pecan nut casebearer and pecan aphids.

Carbaryl: The rate of application is 1.2 - 2.4 lb/100 gallons of water. This chemical is highly toxic to bees exposed to direct treatment or residues on crops.

Other chemicals registered for pecan weevil control is phosalone, toxaphene (being RPAR'd) azinphosmethyl, parathion and malathion.

3. Use of Pesticide in Producing Commodity

In previous reports, field tests of EPN showed satisfactory control of the pecan weevil and hickory shuckworm (65,121,122,126,128). It is applied as a foliar spray, usually with ground equipment (very seldom by aircraft). A rate of 0.42 - 0.5 pound AI per 100 gallons water (EC,WP) for both insects. For shuckworms, three applications at two week intervals when nut shells begin to harden is recommended. For pecan weevil control, apply foliar application every seven to ten days from the time that pecan shells begin to harden (About August 10-15) until mid-September (166).

Do not graze livestock in treated areas. Do not apply within 21 days of shuck split. EPN is highly toxic to bees exposed to direct treatment or residues on crops.

Chemical Control: A thorough cover spray is necessary for satisfactory control. In pecan groves, cover sprays are applied with air blast or air delivery sprayers, high pressure or hydraulic sprayers, mist-blower concentrate sprayers and in some instances by aircraft. The gallons of finished spray necessary for adequate coverage depends on the size of tree and the type of equipment available. Table 26 gives the approximate gallonage of finished spray per acre required for good coverage on trees of various sizes with the different types of equipment.

[illegible] per season. Do not apply the chemical after shucks have split.
[illegible] registered for control of hickory shuckworm, pistlebugs, pecan [illegible] or nutcaster and pecan aphids.

[illegible] Carbaryl: The rate of application is 1.2 - 2.4 [illegible] 2100 [illegible] [illegible] per. This chemical is highly toxic to bees exposed to [illegible] [illegible] or residues on crops.

Other chemicals registered for pecan weevil [illegible] the [illegible] [illegible] (being EPA 4) azinphosmethyl [illegible] [illegible]

Use of Pesticide in Producing Commodity

In previous reports, field tests [illegible] of the pecan weevil and hickory shuckworm [illegible] [illegible] applied as a foliar spray usually [illegible] ground [illegible] (or by aircraft) A [illegible] of [illegible] - [illegible] [illegible] [illegible] (ND,NT) for both insects. For shuckworm three [illegible] at two week intervals when nut shells begin to harden [illegible] [illegible] pecan weevil control, apply foliar applications every [illegible] from the time that pecan shells begin to harden [illegible] [illegible] until mid-September (166).

Do not graze livestock in treated areas. Do not apply [illegible] [illegible] of shuck split. [illegible] is highly toxic to bees exposed to [illegible] or residues on crops.

[illegible] Control: A thorough cover spray is necessary for [illegible] [illegible] In pecan groves, cover sprays are applied with air blast [illegible] delivery sprayers, high pressure or hydraulic sprayers, mist-[illegible] concentrate sprayers and in some instances by aircraft. The [illegible] finished spray necessary for adequate coverage depends on [illegible] and the type of equipment available. Table [illegible] gives [illegible] volume of finished spray per acre required for [illegible] [illegible] the different types of equ[illegible]

Table 26. Gallons finished spray per acre to get adequate coverage using different types of equipment.

TABLE I

Type of Equipment	Gallons of Spray per Acre by Tree Height Small (under 25 ft.)	Medium (25-35 ft.)	Large (over 35 ft.)
Air-Blast	40-100	50-150	75-300
Hydraulic	150	200	300
Mist-Blower	30	40	50
Airplane	15	20	25

Conventional high volume hydraulic sprayers are suitable for spraying trees of any size, but should be used in smaller groves of 20 to 30 acres or less. This type of equipment requires two or three operators and can spray only from one-third to one-half as many acres per day as an air-blast sprayer.

Air-blast sprayers should be used in pecan groves of approximately 40 acres or larger. Adequate coverage is obtained by spraying both sides of a tree or in some cases, it might be necessary to circle larger trees.

Mist-blowers are smaller than either convention hydraulic or air-blast sprayers. Adequate cover sprays can be achieved with this type of equipment if the sprayer is equipped and powered to cover large trees (36,53).

ATTACHED STATEMENTS

Several comments were received from State and Federal entomologists. These statements are given by state (with limited editing) as follows:

Telephone conversations with Dr. David Boethel, Associate Professor of Entomology, Pecan Research and Extension Station, Louisiana State University, and Dr. W. W. Neel, Professor, Department of Entomology, Mississippi State University, informed that no known use of EPN existed for control of pecan insects within their respective states. Dr. Boethel stated, "that it is doubtful any EPN use exists for pecan in the pecan growing areas of this country".

Dr. Ted Brooks, Extension Specialist, Entomology, Mississippi State University, in a telephone conversation informed that EPN is retained in their Pecan Insect Control Guide but seriously doubted that any use was made in the past two years for pecan pests.

Dr. Gene R. Strother, Extension Entomologist, Auburn University, Auburn, Alabama, included EPN in recommendation for pecan weevil, Hickory Shuckworms and Pecan Nut Casebearer. EPN appears to be more economical and as effective as currently used products such as Sevin. However, only limited use of EPN occurred on Pecan in 1979.

Dr. John Durkin, Extension Entomologist, University of New Mexico, Las Cruces, New Mexico, informed that EPN is not recommended or used for control of Pecan insects in New Mexico.

Dr. H. C. Ellis, Extension Entomologist, University of Georgia, informed that current use of EPN on pecans in Georgia is still used occasionally for control of the pecan weevil, and is sometimes used for stink bug control. One or two applications per year are made on possibly 1,000-1,500 acres of pecans (1 - 1½% of our commercial pecans). The usual rate on pecans is three-fourths to one pound AI per acre.

Dr. Timothy W. Hunt, Research Associate stated that in North Carolina the recommendation of the use of EPN on pecans was done to give an alternate chemical that could be used. Other insecticides are registered which give adquate control and are less hazardous to apply.

The loss of EPN at the present time would pose no economical difficulties for either producers or consumers in North Carolina.

Dr. C. S. Gorsuch, Entomologist, Clemson University, informed that at the present time EPN is included in the pecan insect control recommendations for control of aphids, fall webworm, hickory shuckworm, mites, and pecan nut casebearers.

However, very little, if any, EPN is currently used on pecans in South Carolina.

Timothy W. Kent, Research [illegible] that in Kent[illegible]

the recommendation of the use of EPN on peaches was [illegible]

alternate chemical that could be used. Other [illegible]

registered which give adequate control and are less hazardous

The loss of EPN at the present time would be [illegible]

either growers or consumers in [illegible].

C. [illegible], Entomologist, Clemson University: [illegible]

the present time EPN is included in the [illegible] recommendations for control of aphids, fall webworm, [illegible] mites, and pecan nut casebearers.

However, very little, if any, EPN is currently used on pecans in [illegible].

Pecan

Pecan Pecan weevil and hickory shuckworm

Federal Label Directions:

Ground equipment: Pecan weevil and hickory shuckworm - Apply 0.42 lb - 5 lb ai per acre as a foliar spray.

Air equipment: Pecan weevil and hickory shuckworm - Apply 1-2 lb ai per acre in minimum of 3-10 gal. of finished spray.

Do not apply within 21 days of harvest through 0.5 lb ai per acre. Do not graze livestock in treated groves.

Pecans (Georgia) Pecan weevil and hickory shuckworm

Apply 0.42-0.5 lb ai per acre with ground equipment. All applicable directions, restrictions and precautions on EPA registered label are to be followed

---

Parameters for control of pecan weevil and hickory shuckworm on pecans

Form		5 lb EC or 25% WP
Package size		10 lb bag (WP)
		5 gal. drum (5 EC)
Equipment[1/]	Air:	Fixed wing or helicopter
	Ground:	Air-blast, hydraulic or mist blower sprayers
% applied by air		± 10%
% ground appl. custom applied		± 10%
Rate of application		
Carrier		Water
Approximate # applications/A		3 (HS)-4-5-(PW)
Season		Summer
Vol. finished spray/A[2/]	Air:	5-25
	Ground:	40-300 (air-blast)
		150-300 (hydraulic)
		30-50 (mist blower)

	Air-blast	Hydraulic
Avg. load capacity	500 gallons	300-500 gallons
psi	-	400-600
Nozzles	?	up to 35 gpm
Droplet size	100-250 microns	>400 microns
Hrs./day suitable for spraying	1-3 hrs	3-5 hrs
#Applicators/sprayer	1	2-3
Gal. required to spray 12 trees/A	100 gallons	200 gallons
Speed of spraying	1-3 mph	-

# Acres medium trees (12/A) sprayed/hr	4-5 acres	1-2 acres
Actual spray time/A (not incl. turns, et.)	4-6 min	12-15 min (2-gun)
# Hours actually spraying	± 50% overall	± 50% overall
Refill time	5-10 min	5-10 min

Est. # acres treated with EPN (1979)	5,000
Est. # acres treatments (1979)	
Est. # total pounds EPN applied (1979)	
Est. % of groves treated with EPN (1979)	1 - 1½%
Est. # of growers using EPN (1979)	200
Est. # applicators	?
Est. # mixers/loaders	1 per applicator
Est. # flaggers	None

1/ Proportion of acreage treated with different types of sprayers is unknown. However, large growers use air-blast sprayers, these sprayers become uneconomical when producing groves are less than 40 acres. Growers with producing groves of less than 40 acres use hydraulic sprayers, mist blowers or have pesticides custom applied.

2/ The volume of finished spray applied varies with the size and number of trees per acre.

[illegible] XX - [illegible]

[illegible]

[illegible] distribution

[illegible] are grown commercially in essentially [illegible].

However, there are a few other states that are [illegible]

insignificant peach acreage which is not [illegible]

California leads the nation in production, South [illegible]

second, followed next by Georgia, Pennsy[illegible] New Jersey and

the lesser states. Please refer to [illegible] Report

page 110 of Clemson University [illegible]

of significant states. [illegible] small Florida [illegible]

(33rd state) is indicated separately from [illegible]

b. Acreage and/or number of units

The total number of acres pla[illegible] U.S. is [illegible]

able at this time.

Peaches are generally planted [illegible] rate of [illegible]

per acre, the median being 100 trees per acre. [illegible] instances

in Florida, [illegible] may reach a density of [illegible] trees per acre.

[illegible] approximately 33,000 acres of peaches [illegible]

Carolina, 20,000 acres in Georgia [illegible] acres [illegible]

Carolina. Virginia has 3,880 acres of peaches and [illegible]

[illegible] per acre.

[illegible] value of commodity.

In 1979, the total value of both fresh market and pro-

[illegible] in the U.S. (significant states) was $336,408,000.

[illegible] production in 1979 was [illegible] pounds.

[illegible] refer to [illegible] Report" attached.

Peaches

SECTION ~~IX~~ VIII - PEACHES

1. Commodity Information

   a. Geographic distribution.

   Peaches are grown commercially in essentially 33 states. However, there are a few other states that have a small rather insignificant peach acreage which is not included in those totals. California leads the nation in production; South Carolina is second, followed next by Georgia, Pennsylvania, New Jersey and the lesser states. Please refer to the attached "Special Peach Report", page 119 of Clemson University for the detailed listing of the 32 significant states. The small Florida production reference (33rd state) is indicated separately from the listing.

   b. Acreage and/or number of units.

   The total number of acres planted in the U.S. is not available at this time.

   Peaches are generally planted at the rate of 80-120 trees per acre, the median being 100 trees per acre. In some instances in Florida, trees may reach a density of 180-200 trees per acre. There are approximately 35,000 acres of peaches in South Carolina, 20,000 acres in Georgia and 5,000 acres in North Carolina. Virginia has 3,880 acres of peaches and uses a density of 110 trees per acre.

   c. Production and value of commodity.

   During 1979, the total value of both fresh market and processed peaches in the U.S. (significant states) was $336,408,000. The total U.S. production in 1979 was 2,871.5 million pounds. Again, please refer to the "Special Peach Report" attached, pages 115-121.

d. Cultural practices.

Approximately half of the peach orchards in South Carolina are clean cultivated. Perhaps 80% of these use herbicides in their program. The remaining half use clean cultivation and herbicides in the tree rows, and trashy cultivation or permanent sod in the row middles. There is considerably less deep plowing accomplished now because of the root damage it causes.

Tree density per acre varies from approximately 80-90 trees per acre in California up to as high as 180-200 trees per acre in Florida. The early season peaches are grown on smaller trees and have fewer fruit per tree; therefore, more trees per acre. Late season fruit is grown on larger trees with more fruit grown longer, but have fewer trees per acre.

2. Pest Information

EPN is apparently registered for use on the following pests:

Oriental fruit moth	Cottony peach scale (crawlers)
Plum curculio	Olive scale (crawlers)
Peach tree borer	Tarnished plant bug
Lesser peach tree borer	Mites (four species)
Lecanium scale	

The only recent use that is known for EPN on peaches was that used in Georgia during 1979. During 1979, it was used only for catfacing insects. Catfacing insects (as a group) in Georgia includes the tarnished plant bug, stink bugs, leaf-footed bug, and plum curculio. These insects damage the fruit by feeding on the surface. These surface punctures leave scars which enlarge and cause distortions as the fruit enlarges. The adult stage of the plum curculio cause the catfacing damage, whereas either nymphs or adults of the other three insects mentioned cause catfacing damage.

3. Use of EPN on peaches

A telephone canvass was made of 21 of the 33 states in which

Cultural practices.

Approximately half of the peach growers [illegible] are clean cultivated. Perhaps [illegible] that [illegible] their program. The remaining half [illegible] herbicides in the tree rows, [illegible] sod in the row middles. There is considerable [illegible] planting strength [illegible]

The density [illegible] per acre in California up to as high as [illegible] in Florida. The early season [illegible] and have fewer fruit [illegible] Late season fruit [illegible] grown longer, but have fewer [illegible]

Information

[illegible] is apparently registered [illegible] the following [illegible]

Oriental fruit moth	[illegible]
Plum curculio	Olive scale [illegible]
Peach tree borer	[illegible]
Lesser peach tree borer	[illegible]
Lecanium scale	

The only recent use that is known [illegible] was in Georgia during 1979. During 1979, [illegible] insects. Catfacing insects [illegible] tarnished plant bug, stink bugs, leaf-footed bug [illegible] These insects damage the fruit by feeding [illegible] punctures leave areas which [illegible] as the fruit enlarges. The adult stage of [illegible] catfacing damage, whereas [illegible] catfacing damage.

[illegible]

peaches are known to be grown commercially. The peach entomologist and/or the peach fruit specialist in each of these 21 states was contacted. The canvass included the most important peach states, the eastern U.S., plus a few other locations. The 21 states are as follows:

California	New Jersey	Tennesse
Washington	Pennsylvania	North Carolina
Oregon	Delaware	South Carolina
Michigan	Maryland	Georgia
Arkansas	West Virginia	Florida
Texas	Virginia	Alabama
New York	Kentucky	Mississippi

In addition, the peach spray schedules for Idaho, Oklahoma, Indiana and Kansas apparently did not recommend EPN on peaches.

EPN was not used nor recommended in any state, except for the small amount used in Georgia. It is still not recommended in Georgia.

EPN for catfacing insects was applied in Georgia early in the season at the time the petals fall, until, and at the time the shuck falls off the peach. These two sprays are known as "petal-fall" and "shuck-fall" sprays. Shuck-fall is about 10-14 days after petal-fall, but can be as long as 21 days. Actually, catfacing insects continues to cause damage later in the season. Since EPN is registered for these insects, as well as the curculio and the Oriental fruit moth, it could be used if necessary through the sixth cover spray, four weeks before harvest. There is a 21-day preharvest interval required on EPN.

Only the wettable powder product "1½-6 EPN-Sulfur" was used on peaches in Georgia because the early season sprays are often tank mixed with other wettable powder fungicides and are more compatible. The EPN EC would be used on pecans, not peaches.

The estimate from the U. of Georgia peach entomologist was that one application per year was made at 0.8 lb. a.i. per acre.

The acreage of peaches sprayed with EPN during 1979 probably did not exceed 12-13,000, and could have been considerably less. It was apparently used in Virginia until recent years in lieu of parathion, but is no longer recommended there. EPN has a longer residual action than parathion and is consequently useful early in the season for catfacing insects.

EPN would be applied by ground equipment of various types, primarily the air blast or other fixed nozzle "speed" type sprayers, as opposed to the manual hand held spray gun on a hose. Peach spraying is not normally accomplished by aircraft. Only one peach grower in South Carolina uses aircraft for this purpose. The rest use ground equipment.

The following relative details are furnished based on South Carolina information. They should be comparable to Georgia conditions, and they should apply to use of EPN on peaches.

1) Speed of ground sprayer: 2.5 mph
2) Average gallons sprayed per acre: 200 gals.
3) Insecticide carrier: water
4) Average spray tank capacity: 400 gals.
5) Average refill time: 15 minutes
6) Average number of hours per day suitable for spraying: 10 hrs.
7) Average time actually spraying: 7 hrs.
8) Average number of acres treated per hour: 5 acres
9) Nurse tanks: claimed not to be used (although some are actually used), and no data is available.

...rative Extension Service • Clemson University

MARKETING HIGHLIGHTS

SPECIAL PEACH REPORT
5.5.80

This is a summary of the 1979 peach crop information derived from daily market reports and other related data. This information is provided for its historical interest, and for use in planning and marketing future crops.

REVIEW OF THE 1979 SOUTH CAROLINA PEACH SEASON

PRODUCTION: The 1979 South Carolina peach crop totaled 350 million pounds. This represented 9,211,000 3/4 bushel equivalents. The 1979 production was 35 million pounds (921,000 3/4 bushels) greater than the 1978 figure of 325 million pounds.

Of the 350 million pounds total, 343 million pounds were utilized, and 185 million pounds (4,853 thousand 3/4 bushel) were packed and shipped fresh. The recorded packed and shipped peaches at this level represented 54 percent of the total production.

GROWING CONDITIONS: The South Carolina peach crop benefited from ample chilling hours, plentiful rainfall and lack of spring frosts. Due to the favorable weather conditions, fruit set generally was heavy throughout the state.

More adequate rainfall caused the crop to size-up rapidly. Hail damage was severe in a few localities during May. The loss of peaches from this hail damage was offset by excellent size of the peaches throughout the state.

HARVESTING: Harvest began around the middle of May in the Costal Plains which was a week of so earlier than last year. The quality and size of the early varieties were excellent. Volume gradually increased until July when harvest peaked.

COOPERATIVE EXTENSION WORK IN AGRICULTURE AND HOME ECONOMICS — STATE OF SOUTH CAROLINA
CLEMSON UNIVERSITY AND THE UNITED STATES DEPARTMENT OF AGRICULTURE COOPERATING. WAYNE T. O'DELL, DIRECTOR

Harvest of Coronet and Red Haven, both large volume varieties, was in full swing by the week of June 6-12 in the Ridge area. Harvest of Candor and miscellaneous early varieties was underway in the Piedmont. By mid-June harvest of Dixired and Cardinal varieties got started in the Piedmont area. Harvest of the midseason varieties in the first part of July included Red Haven, Garnet Beauty, Harvester, Velvet, Washington and Sunhigh.

The late varieties were being harvested by the last week of July. The Ridge area was picking Blakes as the Piedmont moved into Red Globes, Lorings, and Sunhighs. The Rio-Oso-Gem and Monroe varieties continued into mid-August.

QUALITY: Quality, size and color were excellent this year.

MARKETING: The first F.O.B. report was issued from Columbia, SC, June 5, covering sales of South Carolina peaches. Thirty-eight pound cartons yellow flesh varieties U.S. Extra #1 2¼" up sold at $10.00; 2" up $8.00 some $7.50 and 1 7/8" minimum $6.00 few $6.50. Prices for the month of June remained rather constant especially for the larger sizes with 2¼" up ranging $9.00-$11.00; 2 1/8" up $7.50-$9.50; 2" up mostly $7.00-$8.00 and 1 7/8" minimum $4.00-$6.00. The market declined during July which was the peak harvest month. The week of July 15-21 was the peak week with 659 truckloads being shipped. The market structure during this period was 2¼" $5.50-$7.00; 2 1/8" up $5.00-$6.00; 2" up $4.50-$5.00 and 1 7/8" minimum $4.00-$4.50.

VARIETIES: Some of the main varieties were Condor, Cardinal, Junegold, Earlired, Magnolia, Dixired, Rubyred, Coronet, Redhaven, Washington, Velvet, Redglobe, Loring, Blake, Jefferson, Madison, Monroe, Rio-Oso-Gem, Jersey Queen and Redskin.

TRANSPORTATION: The national truckers strike occurred during the summer. Its effect on the South Carolina peach harvest was significant. While product loss due to the transportation and delivery schedules were the main problems. Drivers were mostly driving during daylight hours to avoid vandelism. They also avoided areas or terminal markets where concentrated strike activity was most serious.

of 78 and Red Haven, both large and...

week of June 6-12 in the Ridge area. Harvest of ... early varieties was underway in the Piedmont ...

Dixired and Cardinal, varieties got started in the Piedmont as ...

of the midseason varieties in the ...

Beauty, Harvester, Velvet, Washington and Sunhigh.

varieties were being harvested by the last week of July. The Ridge ... picking Elbertas the Piedmont moved into ... Elbertas, ...

... The Rio Oso Gem ...

Quality, size and color were excellent ...

ING: The first F.O.B. report was issued ... South Carolina peaches. ...

varieties: U.S. Extra, 2 1/4" up sold ... 7/8" minimum ... Prices for ... constant especially for the larger size with ...

00; 2 1/2" up $7.50-$8.50; 2" up mostly $7.00-$8.00 ... $6.00. The market declined during July which ...

of July 15-21 was the peak week with 653 truckloads ...

Market structure during this period was ... up $4.50-$5.00 and 1 7/8" minimum ...

Some of the main varieties were Goodwin, Cardinal, ... Dixired, Rubired, Coronet, Redhaven, Washington, ... Sunhigh ... Jefferson, Madison, Monroe, Rio-Oso-Gem, ...

TION: The national truckers strike occurred during the ...

th Carolina peach harvest was right ... transportation and delivery schedules were the main ...

Market gluts or oversupply occurred in some markets while shortages developed in others. While product loss was not a serious matter; distrupted marketing patterns could have contributed more seriously to financial losses to the growers and shippers than can be herein analyzed.

—— G. Ansel King, Jr.
Assistant Professor
Department of Agricultural
Economics & Rural Sociology

-12-

WEEKLY PEACH SHIPMENTS IN THE UNITED STATES

38,000 POUNDS (1,000 38-pound cartons)

APRIL THROUGH SEPTEMBER 1979

WEEK ENDING		APLCHN	SOUTH CAROLINA	NORTH CAROLINA	GEORGIA	CALIF	FLORIDA	NEW JERSEY	WASH	MICH	OTHERS	TOTAL
APRIL	28	-	-	-	-	1	-	-	-	-	-	1
MAY	5	-	-	-	-	13	-	-	-	-	-	13
	12	-	-	-	1	14	1	-	-	-	3	19
	19	-	3	-	17	86	24	-	-	-	4	134
	26	-	60	-	119	276	22	-	-	-	12	489
JUNE	2	-	122	-	216	489	19	-	-	-	9	874
	9	-	314	22	202	336	3	-	-	-	9	886
	16	-	315	47	182	358	17	-	-	-	3	922
	23	-	370	36	215	270	19	-	-	-	-	910
	30	-	504	57	183	434	11	-	-	-	-	1,189
JULY	7	-	473	56	159	468	-	-	-	-	-	1,156
	14	2	532	55	129	441	-	-	3	-	-	1,162
	21	28	658	44	134	450	-	51	10	-	-	1,375
	28	47	592	33	94	548	-	78	34	2	-	1,428
AUG	4	68	384	48	21	500	-	158	24	7	-	1,230
	11	153	221	31	-	371	-	221	30	39	-	1,066
	18	147	133	5	-	315	-	205	33	54	-	892
	25	148	99	1	-	253	-	237	41	36	-	815
SEPT	1	145	33	1	-	232	-	304	67	18	6	806
	8	121	26	5	-	206	-	261	69	25	79	792
	15	40	14	2	-	232	-	201	43	22	36	590
	22	8	-	-	-	228	-	137	13	11	-	397
	29	-	-	-	-	143	-	-	9	-	-	152
TOTAL		927	4,553	443	1,672	6,864	116	1,853	376	214	161	17,293

-6-

PEACHES

STATE	PRODUCTION POUNDS UTILIZED 1977	1978	1979	PRICE PER POUND 1977	1978	1979	VALUE OF UTILIZED PRODUCTION 1977	1978	1979
	MILLION UNITS			CENTS			1,000 DOLLARS		
ALA	10.0	15.0	14.0	14.9	16.6	18.5	1,490	2,490	2,590
ARK	39.0	36.0	35.0	11.3	12.5	13.8	4,407	4,500	4,830
CALIF FREESTONE	468.0	394.0	468.0	8.9	11.5	10.9	41,652	45,310	51,012
COLO	14.5	7.2	13.0	13.7	17.7	20.8	1,987	1,274	2,704
CONN	6.0	6.3	5.0	24.0	29.0	32.0	1,440	1,827	1,600
DEL	2.4	2.3	1.5	12.5	10.5	13.0	300	242	195
GA	90.0	120.0	135.0	15.3	15.6	11.3	13,770	18,720	15,255
IDAHO	12.5	11.0	10.5	12.0	12.5	15.0	1,500	1,375	1,575
ILL	9.0	16.0	15.0	16.4	21.9	18.5	1,476	3,504	2,775
IND	1.0	5.0	4.0	23.0	22.0	22.0	230	1,100	880
KANS	9.0	5.0	5.0	15.0	17.6	25.0	1,350	880	1,250
KY	.1	11.0	15.0	14.6	20.0	21.0	15	2,200	3,150
LA	6.5	6.5	7.0	20.0	20.0	23.0	1,300	1,300	1,610
MD	21.0	24.0	21.0	13.5	13.3	14.3	2,835	3,192	3,003
MASS	3.5	3.5	3.3	22.0	29.0	32.0	770	1,015	1,056
MICH	55.0	60.0	35.0	15.6	16.0	19.4	8,580	9,600	6,790
MISS	4.0	4.0	3.0	17.0	20.0	20.0	680	800	600
MO	11.0	14.0	12.0	20.0	16.0	21.5	2,200	2,240	2,580
N J	110.0	70.0	90.0	17.0	23.6	16.9	18,700	16,520	15,210
N Y	13.0	16.0	6.7	17.5	18.5	22.2	2,275	2,960	1,487
N C	35.0	45.0	50.0	12.4	16.0	16.3	4,340	7,200	8,150
OHIO	3.0	5.0	4.0	23.5	23.7	26.0	705	1,185	1,040
OKLA	9.5	8.5	12.0	11.5	14.2	15.2	1,093	1,207	1,824
OREG	18.0	13.0	16.0	14.7	17.9	19.2	2,646	2,327	3,072
PA	95.0	85.0	90.0	12.9	15.8	14.8	12,255	13,430	13,320
S C	267.0	300.0	343.0	14.2	15.5	13.9	37,914	46,500	47,677
TENN	8.0	8.4	8.5	13.0	16.0	17.0	1,040	1,344	1,445
TEX	46.0	37.0	34.0	14.0	17.0	20.0	6,440	6,290	6,800
UTAH	17.5	15.0	18.0	12.6	17.0	17.0	2,205	2,550	3,060
VA	19.0	40.0	32.0	12.0	14.3	13.2	2,280	5,720	4,224
WASH	41.0	38.0	31.0	10.3	14.4	16.2	4,223	5,472	5,022
W VA	14.7	25.0	24.0	14.5	17.8	16.8	2,132	4,450	4,032
TOTAL ABOVE	1,459.2	1,446.7	1,561.5	12.6	15.1	14.1	184,230	218,724	219,818
CALIF CLINGSTONE	1,393.0	1,110.0	1,310.0	7.0	8.1	8.9	97,510	89,910	116,590
U S	2,852.2	2,556.7	2,871.5	9.9	12.1	11.7	[illegible]	308,634	336,408

-11-

COMBINED RAIL & TRUCK CARLOADS (38,000 LBS) IN 41 CITIES
APRIL THROUGH DECEMBER 1979

3

	CA	FL	GA	MD	NJ	NC	PA	SC	VA	WV	OTHERS	TOTALS
ALBANY, NY	1	6	5	0	25	6	6	80	0	6	2	141
ATLANTA, GA	2	1	116	1	0	7	2	140	3	2	0	280
BALTIMORE, MD[1]	10	9	19	12	13	46	4	40	0	5	0	158
BIRMINGHAM, AL	1	0	0	0	1	2	0	4	2	1	15	26
BOSTON, MA	19	13	80	5	130	15	20	323	7	7	0	620
BUFFALO, NY	8	3	12	1	9	18	4	34	1	1	3	94
CHICAGO, IL	147	0	127	6	33	115	6	149	3	39	74	700
CINCINNATI, OH	15	0	38	0	10	1	0	86	0	1	4	156
CLEVELAND, OH	21	0	12	0	19	33	3	164	5	29	27	314
COLUMBIA, SC	0	0	0	0	[illegible]	0	0	143	0	0	0	146
DALLAS, TX	154	0	2	0	0	0	0	0	0	0	37	193
DENVER, CO	161	0	0	0	0	0	0	0	0	0	72	233
DETROIT, MI	81	4	29	2	37	24	0	164	0	6	6	353
FORT WORTH, TX	22	2	0	0	0	0	0	0	0	0	0	24
HOUSTON, TX	188	0	33	5	0	8	0	27	3	0	39	305
INDIANAPOLIS, IN	21	8	16	2	2	3	6	28	0	1	1	89
KANSAS CITY, MO	128	0	4	0	3	0	2	1	0	0	7	145
LOS ANGELES, CA	1,128	0	0	0	0	0	0	0	0	0	1	1,129
LOUISVILLE, KY	7	0	11	1	0	4	10	38	0	9	4	85
MEMPHIS, TN	8	4	0	0	2	2	0	6	0	1	4	27
MIAMI, FL	23	1	47	0	17	51	0	19	1	0	1	160
MILWAUKEE, WI	54	0	0	5	2	0	5	22	0	0	17	105
MINNEAPOLIS, MN[2]	192	0	1	0	0	0	0	0	0	0	37	230
NASHVILLE, TN	11	8	4	0	0	3	0	16	4	0	4	51
NEW ORLEANS, LA	88	0	1	0	1	0	0	34	0	0	15	140
NEW YORK, NY[3]	67	97	150	0	343	168	89	666	6	11	11	1,611
OKLAHOMA CITY, OK	40	0	1	0	0	0	0	0	0	0	6	48
PHILADELPHIA, PA	23	1	71	0	134	27	9	219	0	5	1	490
PITTSBURGH, PA	13	9	31	0	33	36	40	143	3	31	0	338
PORTLAND, OR	76	0	0	0	0	0	0	0	0	0	39	115
PROVIDENCE, RI	8	1	0	0	3	25	0	39	0	0	0	76
ST. LOUIS, MO	65	1	35	2	3	7	0	41	0	0	92	247
SALT LAKE CITY, UT	72	0	0	0	0	0	0	0	0	0	4	76
SAN ANTONIO, TX	39	0	2	0	15	3	0	9	0	0	50	117
SAN FRANCISCO, CA[4]	521	0	0	0	0	0	0	0	0	0	3	523
SEATTLE, WA[5]	99	0	0	0	0	0	0	0	0	0	97	196
TOTAL U. S.•	3,513	170	847	43	647	604	206	2,515	38	155	673	9,742
MONTREAL, QUE	58	44	30	0	81	22	0	85	0	0	102	426
OTTAWA, ONT.	14	0	0	0	[illegible]	2	0	21	0	0	86	124
TORONTO, ONT.	108	8	34	0	33	25	0	156	0	0	104	467
VANCOUVER, BC	48	0	0	0	0	0	0	0	0	0	49	97
WINNEPEG, MAN	41	0	0	0	0	0	0	4	0	0	39	87
TOTAL CANADA•	[illegible]	56	64	0	[illegible]	49	0	263	0	0	380	1,201
GROUP TOTAL•	3,785	226	911	43	[illegible]	653	206	2,898	38	155	1,053	10,943

•THESE FIGURES WERE CONVERTED TO 38,000 POUND TRUCKLOADS FROM 10,000 POUND UNITS. THEREFORE, TOTALS MAY NOT ADD BECAUSE OF ROUNDING.

1/INCLUDES WASHINGTON, DC
2/INCLUDES ST. PAUL, MN
3/INCLUDES NEWARK, NJ
4/INCLUDES OAKLAND, CA
5/INCLUDES TACOMA, WA

DAILY FOB PRICES AT SOUTH CAROLINA SHIPPING POINT

FOB prices in the following table are for 3/4 bushel cartons and crates, various varieties yellow flesh US Extra No. 1. Hydrocooling included.

DATE		2½" up	2¼" up	2 1/8" up	2" up	2" min	1 7/8" min
June	5	10.00	-	-	7.50- 8.00	-	6.00- 6.50
	6	10.00	-	-	7.50- 8.00	-	6.00- 6.50
	7	9.50-10.00	-	-	7.50- 8.00	-	5.50- 6.00
	8	10.00-10.50	-	-	7.00- 8.00	-	5.50- 6.00
	11	10.00-10.50	-	-	7.50- 8.00	-	5.50- 6.00
	12	10.00	-	-	7.50- 8.00	-	5.00- 5.50
	13	10.00-10.50	-	-	8.00- 9.00	-	5.00- 5.50
	14	10.00-10.50	-	-	8.00- 9.00	-	5.00- 6.00
	15	10.00	-	-	8.00- 9.00	-	5.50- 6.00
	18	10.00-11.00	-	9.00	8.00	-	5.00- 5.50
	19	10.00-10.50	-	9.00	8.00- 8.50	-	5.00- 6.00
	20	10.00-10.50	-	9.00	8.00- 9.00	-	5.00- 5.50
	21	10.00-11.00	-	9.00	8.00- 9.00	-	5.00- 6.00
	22	10.00-11.00	-	-	8.00- 9.00	-	5.00- 6.00
	25	10.00-11.00	-	-	8.00- 9.00	-	5.00- 6.00
	26	10.00-10.50	-	9.00- 9.50	7.50- 8.50	-	5.00- 6.00
	27	10.00-10.50	-	8.00- 9.00	7.00- 8.00	-	4.50- 5.50
	28	9.00-10.50	-	8.00	7.00- 8.00	-	4.00- 5.00
	29	9.00-10.00	-	7.50- 8.00	6.00- 7.00	-	*
July	2	8.00- 9.00	-	7.00- 8.00	6.00- 6.50	-	3.50- 4.50
	3	7.50- 8.00	-	6.50- 7.00	5.50- 6.00	5.00- 5.50	3.50- 4.50
	4	----------	----------	-HOLIDAY-	----------	----------	----------
	5	6.00- 7.50	-	6.00	5.00- 5.50	*	*
	6	6.00- 7.00	-	5.50- 6.00	5.00	*	*
	9	6.00- 7.00	-	5.00- 6.00	4.50- 5.00	3.50- 4.00	*
	10	5.50- 7.00	-	5.00- 6.00	4.50- 5.00	4.00- 5.00	-
	11	6.00- 7.00	-	5.00- 6.00	4.50- 5.00	4.00- 4.50	-
	12	6.00- 7.00	-	5.00- 6.00	4.50- 5.00	4.00- 5.00	-
	13	6.00- 7.00	-	5.00- 6.00	4.50- 5.00	4.50- 5.00	-
	16	6.00- 7.00	10.00	5.00- 5.50	5.00	4.50	-
	17	6.00- 7.00	7.00-10.00	5.00- 6.00	4.50- 5.00	4.00- 4.50	-
	18	5.50- 7.00	7.00-10.00	5.00- 6.00	5.00	3.75- 4.00	-
	19	5.50- 7.00	6.00- 7.50	5.00- 5.50	4.50- 5.50	*	-
	20	5.50- 6.50	6.50- 7.50	5.00- 5.50	4.50- 5.00	*	-
	23	5.50- 7.00	7.00- 7.50	5.00- 5.50	4.50- 5.00	4.00- 4.50	-
	24	5.50- 7.00	7.00- 7.50	5.00- 5.50	4.00- 5.00	4.00	-
	25	5.50- 6.00	7.00- 7.50	5.00- 5.50	4.00- 5.00	- 4.00	-
	26	5.50- 6.50	7.00- 7.50	5.00- 5.50	4.00- 5.00	4.00	-
	27	5.50- 6.50	7.00- 7.50	5.00- 5.50	4.50- 5.00	4.00- 4.50	-
	30	6.00- 6.50	7.00- 7.50	5.50	4.50- 5.00	4.00- 4.50	-
	31	6.00- 6.50	7.00- 7.50	5.50	4.50- 5.00	4.00- 4.50	-
Aug	1	6.00- 6.50	7.50- 8.00	5.00- 6.00	4.50- 5.00	4.00- 4.50	-
	2	6.00- 6.50	7.50- 8.00	5.00- 6.00	4.50- 5.00	4.00- 4.50	-
	3	6.00- 6.50	7.50- 8.00	5.00- 6.00	4.50- 5.00	4.00- 4.50	-
	6	6.50- 7.00	-	5.50- 6.50	5.00- 5.50	4.00- 5.00	-
	7	7.00- 7.50	9.00	6.50- 7.00	*	*	-
	8	7.50- 8.00	9.00	6.50- 7.00	*	5.00- 6.00	-
	9	7.50- 8.00	-	6.50- 7.00	*	5.00- 6.00	-
	10	7.50- 8.00	-	6.50- 7.00	*	*	-
	13	8.00- 8.50	9.00- 9.50	7.00- 7.50		*	-
	14	8.00- 8.50	-	7.00- 7.50	6.00	*	-
	15	8.00- 8.50	-	7.00- 7.50	6.00- 6.50	*	-
	16	8.00- 8.50	-	7.00- 7.50	6.00	*	-
	17	8.00- 8.50	-	7.00- 7.50	7.00	*	

*INSUFFICIENT TO QUOTE.

Exposure
Hazards

X. EXPOSURE HAZARDS

A. PRESUMPTIONS

On September 19, 1979, the Environmental Protection Agency issued a "Rebuttable Presumption Against Registration and Continued Registration of Pesticide Products Containing EPN:" (Federal Register 44 (183), 54384-54416 (September 19, 1979). The Agency's action was based on the following presumptions:

1. Delayed Neurotoxicity

40 CFR 162,11 (a)(3)(ii)(B) provides that a rebuttable presumption shall arise if a pesticide "(p)roduces any other chronic or delayed toxic effect in test animals at any dosage up to a level, as determined by the Administrator, which is substantially higher than that to which humans can reasonably be anticipated to be exposed, taking into account ample margins of safety***."

On the basis of scientific studies and information summarized in the Position Document, the Agency has concluded that all registrations and applications for registration of pesticide products containing EPN exceed this risk criterion for delayed neurotoxicity and that a rebuttable presumption against new or continued registration of such products has arisen.

2. Acute Toxicity: Hazard to Wildlife, Aquatic Species

40 CFR 162,11 (a)(3)(i)(B)(3) provides that a rebuttable presumption shall arise if a pesticide's use "(r)esults in a maximum calculated concentration following direct application to a six-inch layer of water more than one-half the acute LC_{50} for aquatic organism representatives of the organisms likely to be exposed as measured on test animals specified in the Registration Guidelines."

On the basis of scientific studies and information summarized in the Position Document, the Agency has concluded that all registrations and applications for registration of pesticide products containing EPN, which are applied directly to water, exceed this risk criterion, and that a rebuttable presumption against new or continued registration of such products has arisen.

3. Additional Grounds for Review

The Position Document contained some data associating EPN with teratogenic and muscular effects, cholinergic effects, disorders of the eye, possible mutagenic effects, potentiation of other compounds by EPN, and reduction in population of nontarget organisms. The data and analyses available at that time with respect to those effects were not sufficient to warrant the issuance of a Rebuttable Presumption. The Agency specifically solicited further evidence bearing on these possible adverse effects, including analysis thereof, to provide a basis for a final decision on registering pesticides containing EPN.

B. DISCUSSION OF PRESUMPTIONS

1. Delayed Neurotoxicity

The Agency has concluded that all pesticides containing EPN exceed the chronic risk criterion relating to delayed neurotoxicity. Histopathologically, as described by Johnson (72), delayed neurotoxicity appears to be a dying back of the axonal region of the neuron with secondary damage to the myelin sheath. The phenomonon is initiated by some organophosphorus compounds such as triorthocresyl phosphate (148) and leptophos (2). The characteristic clinical symptom in sensitive species is ataxia which usually appears several days after exposure. Because of its sensitivity, the chicken hen has been the species of choice in neurotoxicity testing.

On the basis of scientific studies and information [illegible] in the Position Documents, the Agency has concluded that all [illegible] tions and applications for registration of pesticide [illegible] containing EPN, which are applied directly to water, exceed this risk criterion, and that a rebuttable presumption against [illegible] continued registration of such products has arisen.

3. Additional Grounds [illegible]

The Position Document [illegible] associated [illegible] teratogenic and mutagenic effects, [illegible] disorders [illegible] the eye, [illegible] effects, [illegible] other compounds by EPN, and reductions in populations of nontarget organisms. The data and analyses available at that time [illegible] with respect to these facts were not sufficient to [illegible] the issuance of a [illegible] Presumption. The Agency specifically solicited further [illegible] bearing on these possible adverse effects, including analyses to provide a basis for a final decision [illegible] pesticides containing EPN.

DISCUSSION OF [illegible]

1. Delayed Neurotoxicity

The Agency has concluded that all pesticides containing [illegible] exceed the chronic risk criterion relating to delayed neurotoxicity. [illegible] athologically, as described by Johnson (7), delayed neur[illegible] toxicity appears to be a dying back of the axon [illegible] [illegible] on with secondary damage to the myelin sheath. The phenomenon [illegible] is initiated by some organophosphorus compounds such as [illegible] cresyl phosphate (133) and leptophos (7). The characteristic clinical symptom [illegible] sensitive [illegible] is ataxia which usually appears several

There are 13 studies that are referenced in regard to delayed neurotoxicity in chickens:

1. A Communicable Disease Center test (30) examined the effects of dietary EPN on hens over a 120 day period.

2. Durham et. al. (41) studied effects of subcutaneous EPN on atropinized hens.

3. Witter and Gaines (191) studied the effects of a single subcutaneous dose of EPN on hens.

4. Aldridge and Barnes (3) studied the effects of a single subcutaneous dose of EPN-oxon on hens.

5. Gaines (52) examined the effects of a single subcutaneous dose of EPN on atropinized chickens.

6. Frawley (51) studied the effects of dietary EPN on hens over varying periods.

7. Kaneko and Sakamoto (76) examined the effects on hens of two oral doses of EPN, 21 days apart.

8. An Industrial Biotest Laboratories (67) test also examined the effects of hens of two oral doses of EPN, 21 days apart.

9. Ohkawa et. al (120) studied the effects of single intraperitoneal doses of EPN optical isomers on hens atropinized immediately afterward.

10. The DuPont tests (38) are two-year chronic toxicity feeding studies, unfinished at this writing.

11. Sakamoto (142) studied daily dosings of hens with EPN over a 28-day period.

12. Abou-Donia and Graham (1) studied the effects of three months of daily oral doses of EPN on hens.

13. The DuPont tests (39) are a continuation of the two-year feeding studies currently incomplete.

In the study by the Communicable Disease Center (30) muscle weakness in the legs was noted in hens on diets containing 50, 100, and 200 ppm. These were calculated to be 0.6, 1.9 and 1.8, and 2.4 mg EPN/kg, with this symptom beginning as early as 25 and as late as 50 days into the 120-day feeding study. There were no histopathological examinations.

When hens were atropinized before single subcutaneous injections of EPN at 60 mg/kg (41), leg weakness occurred immediately in all animals. The lowest dose producing this effect was 40 mg/kg. Muscle weakness was irreversible, with one survivor exhibiting this symptom 308 days after dosing.

Witter and Gaines (191) dosed hens subcutaneously with a single 60 mg/kg level. Paralysis lasted from the first day throughout the experiment.

Aldridge and Barnes (3) administered single doses of EPN-oxon subcutaneously to hens. At 10 mg/kg, some birds exhibited ataxia characteristic of delayed neurotoxicity. Histologic lesions were observed but not described.

Gaines (52) administered single doses of EPN subcutaneously to atropinized chickens. The lowest dose producing leg weakness was 40 mg/kg while the highest no effect level (NOEL) was 20 mg/kg. Some animals exhibiting leg weakness failed to recover completely beyond the 303-day observation period.

Frawley (51) fed a diet containing 300 to 600 ppm EPN for five to 14 weeks to hens. The hens exhibited progressive muscular weakness and ataxia with eventual inability to stand. Histological examination revealed fragmentation and lysis of axons, swelling of nerve fibers, and myelin degeneration in the sciatic nerve. In a separate study, hens fed 50 ppm over a seven month period demonstrated slight to

In th[illegible] udy by the Commercial [illegible] (??)

weakness in the legs was noted in hens [illegible]

[illegible] 1 ?00 ppm. These were calculated to be 0.?, 1.? and 1.?, and

?6 mg/kg, with the symptom beginning [illegible]

as 50 days into [illegible] 120 day feeding study. There [illegible]

[illegible]ogical examinations

When hens were [illegible] gated [illegible] lo[illegible]

[illegible]ses of EPN at 60 mg/kg [illegible] leg weakness [illegible]

all animals. The lowest level producing [illegible]

[illegible]scle weakness was [illegible]

[illegible] 30?-days after dosing.

Witter and Gaines (1963) [illegible]

60 mg/kg level. Paralysis lasted [illegible] through

the experiment.

Aldridge and Barnes [illegible]

subcutaneously to hens [illegible] exhibit[illegible]

[illegible]teristic of delayed neurotoxicity [illegible]

observed but not described.

Gaines (52) administered single doses [illegible] subcutaneously

[illegible] atropinized chickens. The lowest dose producing leg weakness

[illegible] 40 mg/kg while the highest no effect level (NOEL) [illegible] mg/

[illegible] animals exhibiting leg weakness failed to recover completely

[illegible] the 303-day observation period.

[illegible]y (51) fed [illegible] diet containing 300 to [illegible] for [illegible]

[illegible] hens. The hens exhibited progressive muscular weakness

[illegible] eventual inability to stand. Histological examination

[illegible] and lysis of axons, swelling of nerve [illegible]

[illegible] in the [illegible] separate study

[illegible] administered single [illegible]

moderate clinical signs indicative of delayed neurotoxicity.

Kaneko and Sakamoto (76) gave oral doses of EPN ranging from 22.2 mg/kg to 48.7 mg/kg once at the beginning and again 21 days later. No paralysis was observed in any of the survivors. No description was provided of the clinical status of any of the animals that died during the experiment.

The Industrial Biotest Laboratory study (67) indicated that hens were given a single oral dose of 28.8 mg/kg of EPN at the start and again 21 days later. Hens exhibited severe ataxia, severe lethargy, and anorexia within 30 minutes of each dose. The majority of the survivors were normal within 48 hours of each dose and no behavioral signs of neurotoxicity were noted. Histopathology on the birds did not reveal any axonal degeneration or demyelination.

Ohkawa et. al. (120) administered single intraperitoneal doses ranging from 31.2 to 89.2 mg/kg of the optical isomers of EPN to hens, which were atropinized immediately and six and 24 hours afterwards. Paralysis of the legs developed in the hens dosed with (-) EPN and racemic (+) EPN, occurring ten to 14 days after treatment, and appeared to be irreversible through four weeks observation. No paralysis was observed with the (+) isomer at any level. Histology showed degenerating myelin sheaths and swollen and fragmented axons in the sciatic nerve, and cervical, thoracic and lumbar regions of the spinal cord of the (-) EPN treated hens. The (+) EPN treated hens did not demonstrate these changes. Histopathology was not reported for hens fed the racemic EPN.

The DuPont(38) progress report examined hens fed 0, 1, 5, 15, or 45 ppm dietary for two years. After 31 weeks, most of the survivors on the 45 ppm showed clinical signs of neurotoxicity ranging

moderate clinical signs indicative of delayed n[illegible]toxicity.

Kanero and Wakamura (76) gave oral doses [illegible] EPN ranging from [illegible] 1 mg/kg to 48.7 mg/kg once at the beginning and again 21 days [illegible]. No paralysis was observed in any of the survivors. No [illegible]iption was provided [illegible] the clinical status of any of the ani[illegible] died during the experiment.

The [illegible] results. [illegible] Labor[illegible] study (65) indicates that [illegible] a single oral dose of 23.3 mg/kg of EPN at [illegible] again 2[illegible] days later. Dose exhibited severe ataxia. [illegible] anorexia within 30 minutes of each dose. The majority of the [illegible]vors were normal [illegible] 48 hours of [illegible] and no behavioral [illegible] of neurotoxicity were noted. Histopathology [illegible] did [illegible] reveal any axonal degeneration or demyelination.

Ohkawa et. al. (120) administered single intraperitoneal doses ranging from 31.2 to 80.2 mg/kg of the optical isomers of EPN to hens, wh[illegible] were atropinized immediately and six and 24 hours afterward. [illegible]ysis of the legs developed in the hens dosed with (-) EPN or [illegible] (+) EPN, occurring ten to 1[illegible] days after treatment, and [illegible] to be irreversible through four weeks observation. No para[illegible] was observed with the (+) isomer at any level. Histology [illegible] degenerating myelin sheaths and swollen and fragmented axons [illegible]n the sciatic nerve, and cervical, thoracic and lumbar regions of the spinal cord of the (-) EPN treated hens. The (+) EPN treated [illegible] demonstrate these changes. Histopathology was not re[illegible] hens fed the racemic [illegible]

DuPont(38) progress report examined hens fed [illegible] 1, [illegible] 15, [illegible] dietary for two years. After 31 weeks, most of the sur[illegible] [illegible] clinical signs [illegible]

from slight intermittant to severe ataxia. Ataxia first appeared after 17 weeks. No clinical abnormalities were seen in 0, 1, 5, or 15 ppm EPN. Preliminary histopathology (39) at 50 weeks was reported. Treatment-related changes were observed in the spinal cords and brains of hens fed 45 ppm, while no lesions were attributable to EPN fed at 1, 5 or 15 ppm. No changes were evident in the sciatic nerves of any dose group. This study is incomplete at this writing.

Sakamoto (142) dosed hens with EPN at the rate of 1,3 and 10 mg/kg daily except Sunday's for 28 days, and observed them for an additional 21 days. Approximately one-half of the hens on the highest dosage demonstrated mild ataxia beginning 23 to 42 days from the start. None recovered during the observation period. No ataxia was observed at 1 or 3 mg/kg. Results of histological examinations are not available.

The more recent study of Abou-Donia and Graham (1) seems to have carried the burden of responsibility for the rebuttable presumption of EPA. In these tests, hens were given single daily oral doses of EPN in the range of 0.01, 0.1, 0.5, 1.0, 2.5, 5.0 and 10 mg/kg for three months. Survivors were observed for an additional month. All hens receiving 2.5, 5.0, and 10.0 mg/kg demonstrated acute cholinergic signs shortly after the first dose. Five to 21 days after starting the test, ataxia was observed in all hens receiving EPN at 0.1 to 10 mg/kg. No abnormalities were seen in the animals receiving 0.01 mg/kg.

The severity of clinical symptoms was dose dependent. Even as low as 0.5 mg/kg all hens exhibited total ataxia, while at 0.1 mg/kg, the clinical condition of most of the hens progressed to total ataxia. Histologically, swollen and fragmented sheaths and axons

from slight intermittent to severe ataxia. Ataxia first appear [illegible]

17 weeks. No clinical abnormalities were seen in [illegible]

at 15 ppm EPN. Preliminary histopathology [illegible] weeks was

reported. Treatment-related lesions were detected in the spinal

cords and brains [illegible] hens fed 45 ppm, while no lesions were attrib-

butable to EPN [illegible] at [illegible] and 15 ppm. No [illegible] were evident in

sciatic nerves [illegible] any dose group. This study [illegible] incomplete

at this writing.

Sakamoto (1981) dosed hens with EPN at [illegible] of [illegible]

10 mg/kg daily [illegible]

an additional 21 days. [illegible]

highest dosage demonstrated [illegible]

the start. [illegible]

was observed [illegible] 1 or 3 mg/kg. [illegible] examination [illegible]

are not available.

The most recent study [illegible]

carried the burden of [illegible]

of EPA. In these [illegible] daily [illegible]

in the range of 0.01, 0.1, [illegible] 2.5, 5.0 and [illegible]

[illegible] months. Survivors were observed for an additional month.

[illegible] hens receiving 2.5, 5.0, and 10.0 mg/kg are not included.

[illegible] ataxic signs shortly after the [illegible]

after starting the test, ataxia was observed in all hens [illegible]

0.1 to 10 mg/kg. No abnormalities were seen in the animals

The severe [illegible]

in the spinal cord were found in some of the hens fed 2.5 and 1.0 mg/kg. No histologic abnormalities were found in the hens receiving 0.5 or 0.1 mg/kg, except one hen at the last level which showed perivascular lymphocytic cuffing in the thoracic cord, but no neuronal or myelin degeneration.

Sciatic nerve degeneration was observed only at the two highest levels, 10.0 and 5.0 mg/kg. No lesions were observed in brains or retina and optic nerves of EPN-treated hens.

These studies fall into two categories, daily dosing of hens for an extended period and single doses by different routes. The most sensitive or easily identified clinical response in hens is ataxia and was noted in daily exposure as low as 0.1 mg/kg by Abou Donia and Graham (1), approximately 0.5 mg/kg in the DuPont study (39), 0.5 mg/kg by Frawley (51), and 0.6 mg/kg in the CDC study (30). The highest daily exposures in which no clinical effects were observed were those of Sakamoto (142) in hens dosed with 1 or 3 mg/kg/day and the DuPont (38) study with hens fed approximately 0.2 mg/kg/day.

From these data, it appears that there is a wide variation in response to EPN when using ataxia as the criterion. The most extreme variation is the Sakamoto (142) data indicating no clinical effects at 3 mg/kg while Abou Donia and Graham (1) observed ataxia at 0.1 mg/kg, a 30-fold difference. Excluding these two extremes, the range of no-response doses narrows from 0.2 to 1.0 mg/kg within which the highest no effect level probably lies.

2. Human Exposure

(a) Food Residue

The position taken by EPA on EPN residues in food does not appear valid for cottonseed or other food crops. Under present

use patterns only half of the cotton crop is treated with EPN, thus the residue value for cotton seed oil should be only one-half that calculated for worst-case, 0.00001 mg/kg body weight per day.

For the remainder of food crops, it is inconceivable that residues would occur on all such crops at tolerance. Considering the insignificant use of EPN on food crops, it is extremely unlikely that as much as 10% of the food crops could carry tolerance residues, particularly in view of the Market Basket studies which show no EPN residues at any time. The significance of EPN is such that it is not even listed as a pesticide that is analyzed for in the FDA Market Basket surveys (73,74,97).

The random FDA monitoring survey revealed that EPN was detected nine times in 1978 and only four times in 1979 (131). In this same study, methyl parathion, a companion insecticide, was detected 113 and 58 times, respectively.

Further, the RPAR document presents a calculation of the theoretical daily intake (TDI) of EPN based on the tolerance levels for EPN established in the U.S. for the various foods and the percentage each food contributes to the average daily intake of a 70 kg adult. On this basis, the calculated TDI of EPN is 0.016 mg/kg body weight per day. Considering the present and past use patterns of EPN and the Market Basket studies, this figure is easily ten-fold that which could be encountered under worst-case situation, in that virtually no EPN is found in the diet.

(b) Application Exposure

The Agency has concluded that EPN exposure to aerial and ground applications, field workers and cotton scouts who enter treated

was performed only [illegible] of the cotton crop, it [illegible] with TPP, [illegible] the residue value for cotton seed oil should be only one-half that calculated for woodcocks, 0.00001 mg/kg body weight per day.

For the remainder of food groups, it is inconceivable that residues would occur [illegible] tolerances. Considering the insignificant use of [illegible] food crops, it is extremely unlikely that as [illegible] of the food groups would [illegible] tolerance residue particularly in view of the Market Basket studies which [illegible] residues at any time. [illegible] of [illegible] that it is not even listed as a pesticide that [illegible] for in the FDA Market Basket surveys [illegible].

The random FDA monitoring [illegible] that TPP [illegible] nine times in 1978 and only four times in [illegible]. In [illegible] study, methyl parathion, a competitor insecticide, was [illegible] and 58 times respectively.

Further, the NRRB document presents a calculation of [illegible] theoretical daily intake (TDI) of TPP based on the tolerance levels [illegible] established in the U.S. for the various foods and the percentage each food contributes to the average daily intake of a 70 kg adult. On this basis, the calculated TDI of [illegible] mg/kg body weight per day. Considering the current and past use patterns of TPP, and [illegible] Market Basket studies, this figure is [illegible] which would be encountered under worst case situations, in [illegible]

[illegible]

[illegible]

fields soon after application and to unprotected bystanders does not provide an ample margin of safety. There are few if any data to support this action. For instance, in the Summary of Reported Pesticides Incidents Involving EPN (133), only 16 of 24,320 incident reports, covering 12 years, involved EPN. Of the 16, only 11 were associated with application, or less than one application illness per year attributable to EPN. The applicator-exposure study conducted by Velsicol (176) is the most recent and EPN-directed of any exposure data available. They concluded that dermal exposures were higher than respiratory exposures and that both routes could be reduced by utilizing improved handling techniques and using personal protective equipment. Because flagmen received the greatest exposure, it was recommended that their function be replaced by using fixed landmarks where possible, otherwise they should wear appropriate equipment.

Cotton scouts entering fields treated with EPN are required to wait 24 hours after application, or wear protective clothing. Recent dislodgable studies by Ware (182) show that the half-life of EPN on cotton foliage is approximately 24 hours. This compares with Guthion and Azodrin (21) whose foliage residues decline at about the same rate under Arizona conditions. Two studies involving human reentry into cotton fields treated with Azodrin (183,184) demonstrate red blood cell cholinesterase depression in subjects entering 24 and 48 hours post-treatment. Based on the similarity of cotton foliage residue disappearance, curves of EPN with Azodrin and the higher dermal toxicity of EPN than Azodrin (30-50 vs. 354 mg/kg, respectively), it would seem appropriate to reexamine the 24-hours reentry interval for EPN. With these three papers as a basis, it is recommended that the reentry interval for EPN be increased from 24 to 48 hours.

soon after application and to suggest the hypothesis and provide an ample margin of safety. There are few if any data to support this action. For instance, in the summary of Reported Pesticides Incidents Involving [illegible] (131), only 16 of [illegible] reports, covering [illegible] years, involved EPN. Of the 16, only [illegible] associated with application, or less than one application illness a year attributable to EPN. The applicator-exposure study reported by Velsicol (176) is the most recent and EPN-directed of the [illegible] data available. They concluded that dermal exposures [illegible] than respiratory exposures and that both routes could be [illegible] by utilizing improved handling techniques and using more [illegible] equipment. Because flaggers received [illegible], it was recommended that their function be replaced [illegible] where possible, otherwise they should [illegible] appropriate [illegible].

Cotton scouts entering fields treated with EPN are required to wait 24 hours after application, [illegible] dislodgeable studies by Ware (182) show that the half-life of EPN on cotton foliage is approximately 24 hours. This compares with [illegible] Azodrin (21) whose foliage residue [illegible] at about [illegible] under Arizona conditions. Two studies involving [illegible] into cotton fields treated with Azodrin (183,184) [illegible] cell cholinesterase depression in subjects entering [illegible] post-treatment. Based on the similarity of cotton foliage [illegible] disappearance, curves of EPN with Azodrin and the lower [illegible] toxicity of EPN than Azodrin (30-40 vs. 346 mg/kg), respec[illegible]), it would seem appropriate to recommend the 24-hour reentry [illegible] for EPN. With these three points as a basis, it is recom[illegible] the reentry interval for EPN be set [illegible] 24 to 48

And finally, one of the most significant studies influencing the Agency's RPAR EPN final decision should be the early study examining the effects of ingested EPN on human subjects (108). In these tests, there was conclusive data presented that no observable clinical symptoms were noted in subjects receiving 9.0 mg EPN for 56 days, the quivalent of 0.13 mg/kg/day. Additionally, potentiation was examined with malathion, the classical combination. Even with the maximum daily dose combination (6.0 mg EPN and 16 mg malathion for 42 days), there was only slight (15-20%) depression of plasma and red cell cholinesterase. Apparently potentiation was not observed in that greater red cell ChE depression was found in the subjects receiving 9.0 mg EPN/day alone than in the potentiation tests. Further, there was no evidence of delayed neurotoxicity in the subjects receiving 0.13 mg/kg EPN/day for 56 days. Doubtless this is the most persuasive and to-the-point documentation available for estimating the no-effect-level and determining the probability of delayed neurotoxicity in humans.

3. Acute Toxicity: Hazard to Wildlife

The only use registration for EPN involving direct application to water is its use as a mosquito larvicide. This registration limits use to governmental agencies employing qualified personnel. Application is restricted to standing water such as irrigated pastures and various lowland areas subject to poor drainage. In these areas, little if any, aquatic wildlife is exposed and, thus, there is no unreasonable hazard to aquatic wildlife.

EPN is registered for use by mosquito abatement district personnel, public health officials, and other trained personnel of public mosquito control programs as a mosquito larvicide. These groups employ qualified personnel who are properly instructed and,

nd finally, one of the most significant studies influencing
gency EPAR EPN final decision should be the early and extensive
effects of ingested EPN on human subjects (109). In these tests,
e was conclusive data presented that no observable clinical
oms were ... in subjects receiving 9.0 mg EPN for ... Bone.
quivalent of 0.13 mg/kg/day. Additionally, potentiati
mined with malathion, the classical combination. Even at the
ma num daily dose combination (9.0 ... 16 ... malathion for
42 days), there was only slight (15-20%) lowered plasma and
red cell cholinesterase. Apparently potentiation was ... observed
in that greater red cell ChE depression ... in the
receiving 9.0 mg EPN day alone than ... ... given ... these. Fur-
ther, there was no evidence ...
r eceiving 0.13 mg/kg EPN/day for 30 days. Doubtless these ...
t persuasive and to-the-point documentation available for ...
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3. Acute Toxicity Data to Wildlife

The only use registration for EPN involving direct ... application
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is registered for use by mosquito abatement ... ...
public health officials, and other ... ... personnel ...
... occurs ... ... larvicide, ...
... ...

thus, fully capable of following a well designed label and use directions which should read:

> This product is toxic to fish, birds, and other wildlife. Keep out of any body of water. Do not contaminate water by cleaning of equipment or disposal of wastes.

Unfortunately, all EPN product labels do not contain explicit hazard warning statements similar to these. At least one product does not contain such warning, Reg. #7001-7720.

EPN is applied for mosquito control to water that does not normally contain fish. Moreover, acute effects, if any, would be temporary because EPN is nonpersistent and rapidly degraded (85,75). DuPont found that, "under field conditions, in soil treated with ^{14}C-EPN at a rate of 1.8 pounds active/A, the half-life of intact EPN ranged from about two weeks in a Mississippi test to about one month in a Delaware test." In laboratory water samples of buffered solutions, the half-life of EPN was found to be one to two months at pH 7 and one to two weeks at pH 8 (187); these results were based on residual anticholinesterase activity as a function of time.

Malathion, a chemical even more toxic to aquatic species than EPN (see Table 27), has been a major world-wide mosquito larvicide for many years. EPN and malathion are both nonpersistent organophosphorus insecticides. There is no reason to suspect that EPN represents more a hazard to aquatic wildlife than malathion.

Table 27

COMPARISON OF ACUTE TOXICITY TO AQUATIC WILDLIFE
LC_{50} (PPB)

Species	EPN	Malathion
Rainbow Trout	210*	100*
Bluegill	370*	120*

*USDA Handbook, 1974

When considered with the method of use, labeling and specific directions for use, and widespread and commonly recognized practices of use, EPN is not likely to result in any unreasonable hazard to aquatic wildlife when used as a mosquito larvicide.

4. Other Potential Adverse Effects

The third category of potential adverse effects listed in the EPN RPAR includes teratogenic and muscular effects, cholinergic effects, disorders of the eye, possible mutagenic effects, potentiation of other organophosphate compounds, and reduction in population of nontarget organisms. The categories of potentiation, cholinergic effects, and reduction on nontarget organisms are well established in the scientific literature and with the exception of potentiation, are characteristic of all organophosphate and carbamate pesticides and should not become even potential "triggers" for RPAR of EPN, just as they should not for other OPs and carbamates.

The categories of teratogenic and muscular effects, eye disorders and possible mutagenic effects have been reasonably questioned or discounted in the DuPont, response to the RPAR on EPN (40), that of Marubeni America Corporation (98), and in exhibit 1, o f Nissan Chemical Industries, Ltd. (118). Though these effects are possibilities, they are not supported by adequate published research and should not be used by the Agency in making their final decision on the "Ample Margin of Safety" to personnel working with EPN.

Then considered with the method of use, labeling and specific [illegible]ections for use, and [illegible] commonly recognized [illegible] use, EPN is not likely to result in any unreasonable [illegible] aquatic wildlife when used as a mosquito larvicide.

4. Other Potential [illegible] Effects

The third category of potential adverse effects listed in the EPN PRAR includes teratogenic and neurotoxic effects, [illegible] effect [illegible] of the [illegible], possible mutagenic effects, potential [illegible] of other organophosphate compounds [illegible] reduction in [illegible] of nontarget organisms. The categories of potentiation, cholinergic effects, and reduction in [illegible] [illegible] will [illegible] in the scientific literature [illegible] with the [illegible] of [illegible] are characteristic of all organophosphate [illegible] and [illegible] and should not [illegible] potential [illegible] for [illegible] of E[illegible] just as they should not [illegible] other [illegible] and [illegible].

The categories [illegible] teratogenic [illegible] neurotoxic effects [illegible] and possible mutagenic effects have been [illegible] questioned [illegible] discounted in the [illegible], response to the PRAR on EPN (40), that of Marubeni America Corporation (45), and [illegible] Nissan Chemical Industries, Ltd. (128). Though these effects are [illegible]bilities, they are not supported by adequate published research and should not be used by the Agency in making [illegible]. Final [illegible] the "Ample Margin of Safety" [illegible] personnel working with EPN.

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